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Study of the impact of geothermal energy integration on internal environment of poultry house

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إهــــــــــداء

اللهم لك الحمد حمداً كثيرا طيبا مبارك فيه، نحمدك ربي ونشكرك على أن يسّرت لنا إتمام هذه المذكرة على الوجه الذي نرجو أن ترضى به عنا ....

نتوجه بالشكر إلى كل من استاذتي ومشرفتي الفاضلة " **آسيا مزيان** " التي لها الفضل على البحث والباحث، فلها مني جزيل الشكر كله والتقدير والعرفان.

ونتوجه بالشكر الجزيل إلى جميع الأساتذة الفضلاء في قسم الميكانيك.

وأشكر كل الأهل والأقارب والأصدقاء فلهم في النفس منزلة وإن لم يسعف المقام لذكرهم ، فهم أهل الفضل والخير والشكر

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Poultry House

Introduction

General Introduction:

One of the most significant agricultural sectors in the world is poultry farming, which is essential for meeting the demands of the growing population by supplying animal protein. Both the national economies of many nations and food security benefit greatly from this business. It must overcome several obstacles, nonetheless, in order to create a sustainable and comfortable atmosphere within chicken homes, particularly with regard to heating enough. In order to guarantee poultry's healthy growth and great output, heating is essential. Conventional heating methods, such gas or electric heating, have a detrimental effect on the environment and are frequently expensive and energy-intensive.

Numerous issues plague traditional heating in chicken houses, such as high running costs, unsustainability in the environment, and challenges in maintaining consistent temperature management. Poultry producers have a substantial financial burden because to the expenses associated with fuel and electric heating, which need frequent maintenance and release carbon emissions that worsen global warming. In order to address these problems, it is necessary to look for practical alternatives that will both lessen their negative effects on the environment and enhance the conditions in chicken barns[1, 2].

For heating poultry buildings, geothermal energy is a viable substitute. This energy source provides an effective and long-lasting source of heat by extracting heat from the earth's subsoil. Poultry houses may have comfortable, consistent temperatures inside thanks to geothermal energy, which is a renewable and sustainable energy source that does not require a lot of fuel or power. Furthermore, geothermal heating systems can lower long-term operational costs and lessen dependency on fossil fuels, both of which improve environmental sustainability[3].

The purpose of this study is to investigate how adding geothermal energy affects the temperature, humidity, and air quality within chicken houses. It also attempts to assess the efficiency, affordability, and sustainability of this method in comparison to more conventional methods. The study will examine how geothermal energy may enhance the temperature, humidity, and air quality in poultry houses, as well as the environmental elements that impact these conditions. The study will also include field tests and case studies that highlight the benefits of utilizing geothermal energy in chicken houses.

In this study, we divided the research into three chapters to systematically present information on the topic of geothermal energy and its impact on the indoor environment of poultry houses.

The first chapter provides a comprehensive overview of geothermal energy and previous studies related to this topic. This includes definitions, concepts, and research findings that lay the foundation for understanding the rest of the study.

The second chapter deals with the methods and technologies used in poultry houses, with a focus on their potential impact on the environment. This section discusses how different practices within poultry houses can impact the surrounding environment, especially with regard to air quality and pollution.

Chapter Three shifts the focus to the specific effects of thermal energy on the ecological environment of poultry houses. It studies how temperature, humidity, and air quality inside poultry houses can be affected by the use of geothermal energy.

Finally, the study ends with a general conclusion that combines the most important findings of the research. In addition, an index is provided to help readers navigate the content of the study more easily.

CHAPTER 01

General introduction to Geothermal energy

I. : General introduction to Geothermal energy

I.1 Introduction :

Geothermal energy is a renewable energy source that harnesses the heat stored beneath the Earth's surface. This heat originates from the radioactive decay of minerals in the Earth's crust and the heat leftover from the planet's formation. Geothermal energy can be utilized for various applications, including electricity generation, heating, and cooling systems. The heat from the Earth's interior can be accessed through geothermal power plants, geothermal heat pumps, and direct-use applications such as heating buildings or greenhouses. Geothermal energy is considered a sustainable and environmentally friendly energy source with low greenhouse gas emissions[4].

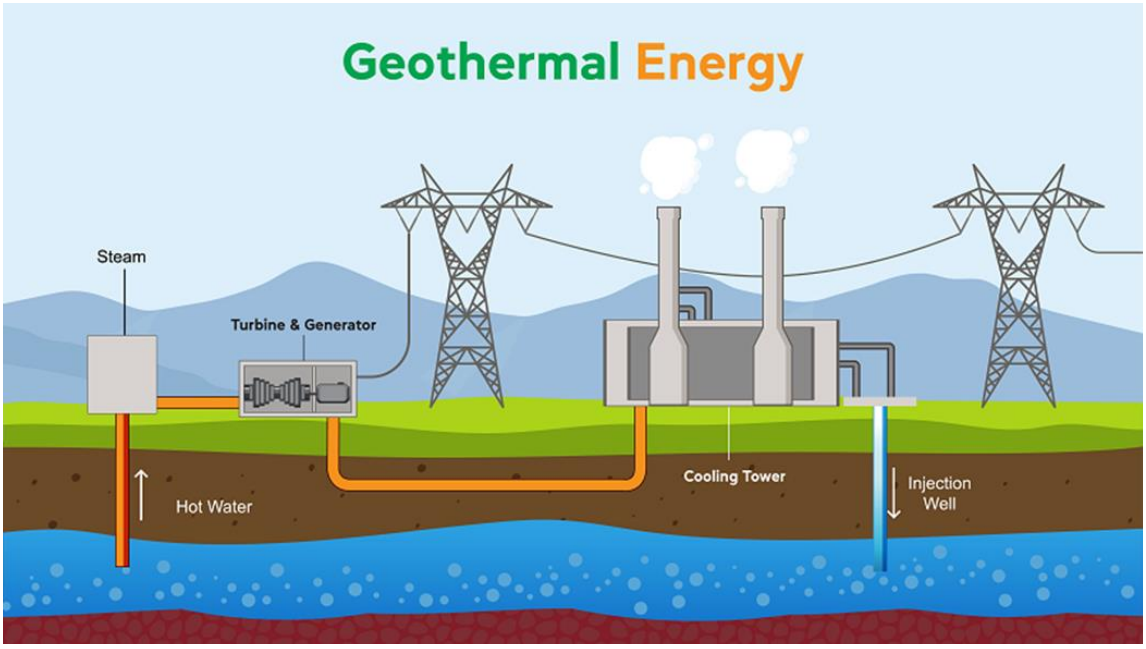

Figure 1 : Geothermalenergy [4]

I.2 History of geothermaldiscoveries

Discoveries verify that the thermal energy created by the earth has been used by mankind since its existence. Since the Paleolithic era, the indigenous American-Paleo Indians employed hot springs for bathing, heating and treating gastric health issues. After that, Romans exploited the water of hot springs for public baths and balneology [5, 6],[7].

Geothermal water was also used by Chinese people in farming and treatment employment from the 4th century. Centuries later, in 1300 AD, the geothermal heat was used for heatingpurposes by the oldest Icelanders. Much later, in the 15th century, the miners observed that below earth's surface the temperature of soil rise with depth , this was reported later by Alexander von Humboldt in the 17th century when he found that the soil temperature increases by 3.8 °C per 100 m increase in depth in Freiberg, Saxony where was the first discovery of the geothermal gradient [6].

I.3 Types of geothermalenergy

Exploitation of geothermal energy depends on the type of geothermal deposits and fluids Thus there are three types of geothermal energy in the world:

I.3.1 High geothermalenergy

High-energy geothermal power exploits deposits of dry or wet steam (a mixture of water and steam). These deposits are characterized by temperatures exceeding 150°C . This high-energy geothermal power is found in volcanic (volcanoes) and seismic (plate boundaries) regions where the geothermal gradient is particularly high. High-energy geothermal power is primarily intended for electricity production. The steam, which is extracted from the geothermal reservoir, is directed into a turbine connected to an alternator for electricity generation. Dry steam is used directly, while wet steam, which is more common, requires the use of a separator[8, 9].

I.3.2 Lowenergygeothermalenergy

Low-energy geothermal energy has a temperature between 30°C and 150°C and is found at an average depth of 1,000 to 2,500 metres. Permeable water-filled formations located mainly in sedimentary basins Large dimensions[10, 11].

I.3.3 Geothermal energy is very low energy

Very low-energy geothermal energy is found at shallow depths (water table) where the temperature ranges from about 10 to 30 degrees Celsius. It is used, among other things, for fish farming, horticulture and drying of agricultural products[11] .

I.4 Geothermalenergy applications

Geothermal energy is a renewable energy source that comes from the heat within the Earth. It has various applications across different sectors due to its reliability, sustainability, and low environmental impact. Here are somecommon applications of geothermalenergy.

I.4.1 Electricity production :

According to the temperature and flow rate of the fluid (steam), geothermal energy can be used to produce electricity. Geothermal power plants can generate electricity in three ways. Despite their design differences, all three control the behavior of steam and use it to drive electrical generators. Since excess water vapor at the end of each process is condensed and returned to the ground, where it is reheated for later use, geothermal energy is considered a form of renewable energy. Some geothermal power plants simply collect rising steam from the ground. In this type of operation, known as "dry steam," the heated steam is directly sent to a turbine that drives an electrical generator. Other plants, built on the model of flash steam and binary cycle, use a mixture of steam and heated water ("wet steam") extracted from the ground to start the electricity production process in dry steam geothermal energy production[12, 13].

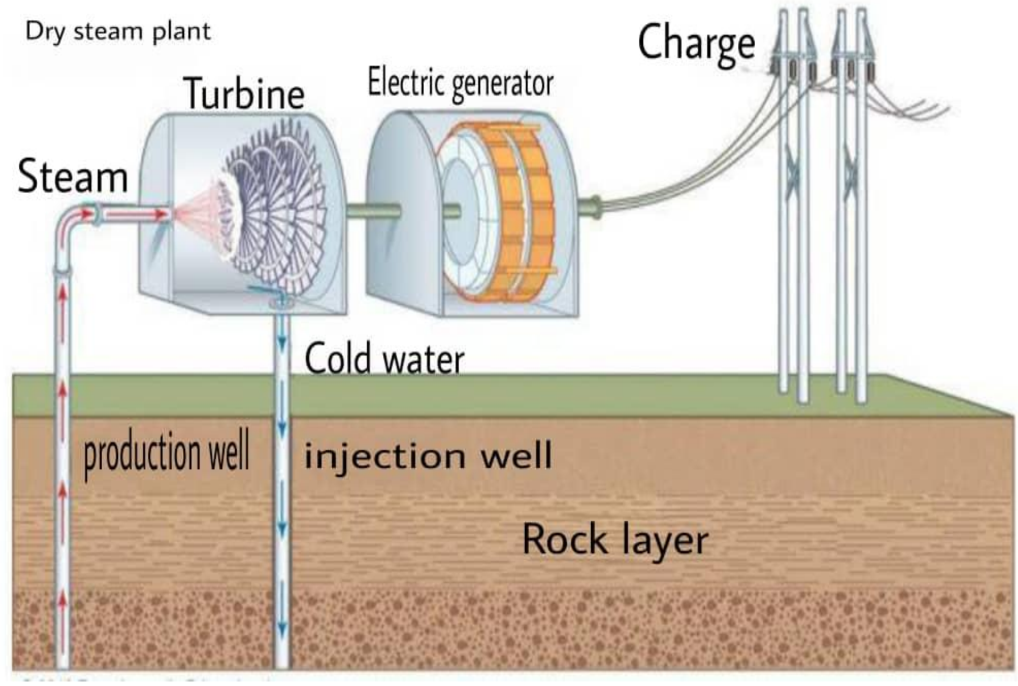

Figure 2 : Dry steam station [13].

In flash steam power plants, pressurized hot water is drawn from the underground into containers at the surface, called flash tanks, where the sudden pressure drop causes the liquid water to vaporize into steam. The steam is then used to power the turbine-generator set. On the other hand, binary cycle power plants use steam from a secondary working fluid (such as ammonia and hydrocarbons) contained in a closed circuit of pipes to power the turbine-generator set. In this process, water heated by geothermal energy is drawn in by another set of pipes, and much of the energy stored in the heated water is transferred to the working fluid through a heat exchanger. The working fluid then vaporizes. After passing through the turbine, the steam from the working fluid is condensed and returned to the heat exchanger[13].

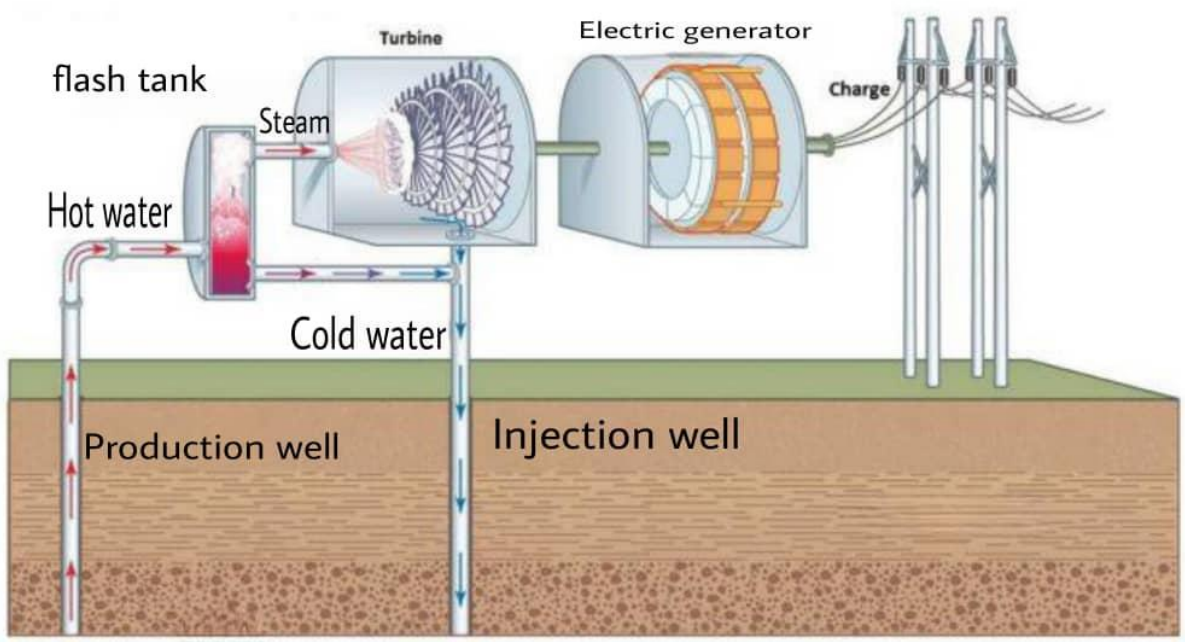

Figure 3 : Flash evaporation station [13].

Electricity generation typically requires water heated to over 175°C (347°F) to be cost-effective. In geothermal power plants using the Organic Rankine Cycle (ORC), a specific type of binary cycle technology that utilizes lower temperature heat sources (such as biomass combustion and industrial waste heat), water temperatures as low as 85-90°C (185-194°F) can be used[12, 13].

I.4.2 Agriculture :

The two main applications of geothermal energy in agriculture are aquaculture (fish farming) and greenhouse cultivation. Greenhouse farming is an attractive option due to its high energy requirements. The largest complexes of geothermally heated greenhouses are found in Italy, Hungary, and Iceland. Regarding aquaculture, an increase in temperature by a few degrees and, more importantly, maintaining it at a constant level, leads to increased metabolism in fish and crustaceans.In the food processing industry, temperatures between 40°C and 100°C are used to dehydrate fruits and vegetables. Above 60°C, heated air can be used for drying agricultural products, fish, and wood[14, 15].

In Algeria, hot water wells that had been used for human consumption and irrigation for decades were only utilized for heating agricultural greenhouses starting from the 1970s. This represented a modest contribution of geothermal energy to the development of the agricultural sector. The heating of greenhouses began in the early 1950s in countries like the Netherlands, Belgium, particularly for ornamental crops. Countries such as Italy, France, and Spain had previously considered that the favorable conditions of sunlight and temperature did not justify such a production tool[14, 15].

Figure 4 : Geothermal agriculture [15].

I.4.3 The heating :

Geothermal energy applied to residential buildings can make use of several different technologies, some of which we will mention.

- **Vertical intake heat pump on tablecloth :**

Two systems are in use. The more environmentally friendly system involves two boreholes. The first borehole receives the well used to draw water, which the heat pump (PAC) will convert into energy. It is located upstream of the groundwater flow direction. The second borehole, dug downstream of the flow, is responsible for returning the cooled water to its natural environment without altering its quality. The other system in use requires only one borehole. The construction site is therefore less costly but does not allow for the replenishment of the water reserve. The discharge is done into a lake, river, stormwater system, etc. This is especially wasteful as the resource is affected by climate change. Groundwater extraction involves the presence of an underground source accessible from the property. It operateswith a water-to-water heatpump[14, 15] ,[13].

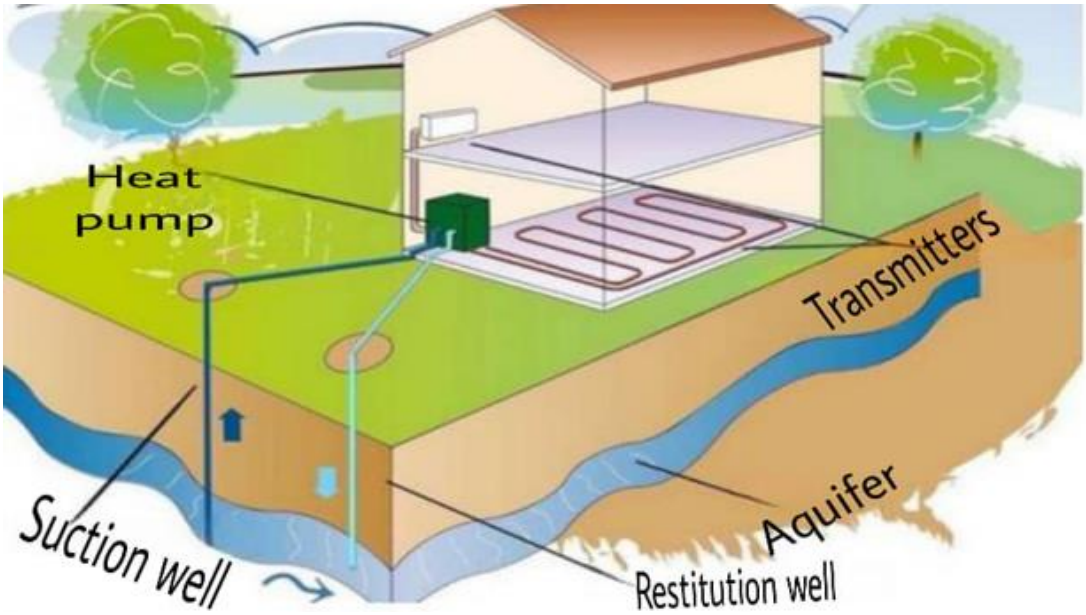

Figure 5 : Compressive force with perpendicular aggregation on the aquifer [14].

- **Horizontal capture heatpump :**

The heat pump (PAC) operates with a network of tubes buried in the garden of the house, about twenty centimeters below the regulatory frost line, at an average depth between 80 and 120 centimeters. These tubes carry a heat transfer fluid that circulates in a closed-loop system. Installed in loops, they are made of copper coated with polyethylene or entirely of HDPE (high-density polyethylene). Three types of heat pumps can be used depending on the characteristics of the network and the domestic installation: ground/water, ground/ground (each for heating only), or glycol-water/water, also known as water/water (capable of providing both heating and cooling) [14, 15].

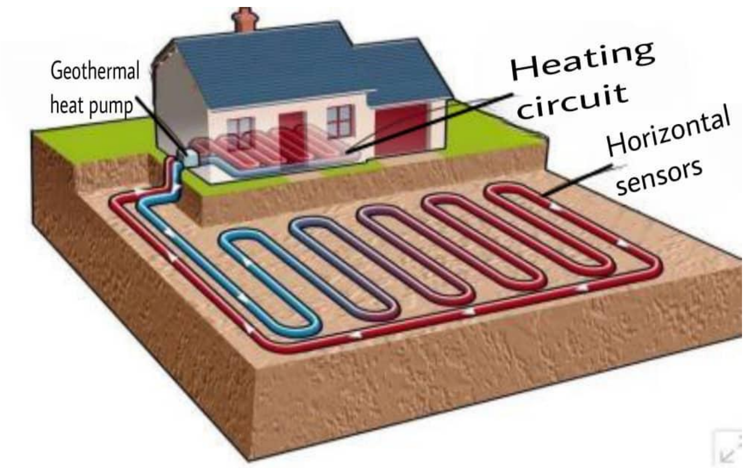

Figure 6 : Geothermal heat pump with horizontal capture[14].

Horizontal ground loop systems require a significant land area, which can be 1.5 to 2 times larger than the area to be heated.

The horizontal ground loop heat pump system is the least expensive of geothermal solutions. It is suitable for gently sloping or ideally flat terrain with good sunlight exposure. Bushes, shrubs, vegetable gardens, etc., can coexist with the network of tubes. However, it is important to ensure that the tubes are placed at least two meters away from trees and three meters away from water pipes.It's good to know that for the installation of a horizontal ground loop, it's preferable to have loose soil rather than rocky soil [15].

- **Heat pump with vertical sensors :**

This process extracts energy from the ground using probes (PEHD tubes) housed in boreholes that can range from a few meters to over 200 meters deep. Vertical borehole heat exchangers offer the advantage of a very small ground footprint. They are also more efficient due to the stability of the heat source at depth. Near the surface, the soil is sensitive to climatic variations. On the contrary, drilling operations require specialized equipment and personnel (RGE QualiForage), which significantly increases the cost of the project. The vertical probes form double loops allowing the flow of fluid to go out and return. The number of probes is calculated based on domestic needs. They are connected to a water-to-water heat pump ,Vertical borehole heat exchangers can be installed near the house and even (prior to construction) beneath the building's crawl space [13, 15].

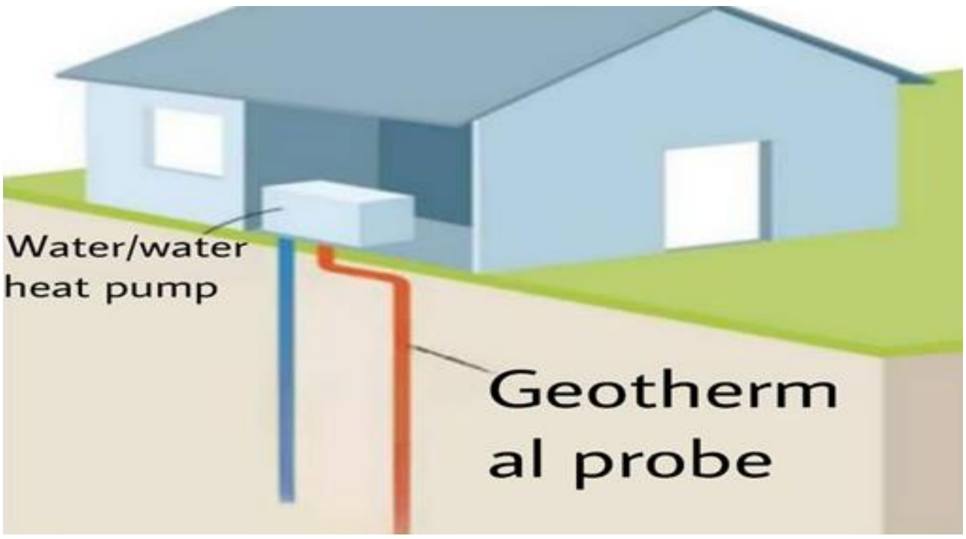

Figure 7 : Vertical capture heat pump[15].

I.5 GeothermalEnergy Extraction :

Manzella (2017) suggests that harnessing energy from underground sources often involves using water as the primary heat carrier. Given the highly fractured nature of the Earth's crust, surface water, particularly rainwater, seeps into the depths where it exchanges heat with rocks. Heat transfer in the crust primarily occurs through conduction and convection. In regions where rocks are extensively fractured and fluid circulation is prevalent, convective heat transfer is highly efficient and easily exploitable through well drilling, allowing hot fluids to be brought to the surface. These convective systems, known as hydrothermal resources, utilize aquifers as geothermal reservoirs.

In areas with exceptionally high heat flow, fluids can reach temperatures exceeding 300°C and may exist as vapor (steam) or water depending on pressure conditions. Fluids of varying temperatures can be extracted from underground and utilized directly for their heat content or to generate electricity. Even at shallower depths, modest temperatures can be tapped for heating or cooling purposes using ground source heat pumps, a widely adopted application of geothermal energy.

The rate at which heat is extracted must be carefully managed to ensure the sustainable utilization of geothermal resources. It is essential that the rate of consumption does not surpass the rate of generation, ensuring that the removed heat is replenished within a comparable timeframe. Geothermal power plants typically operate within specific energy production thresholds. Geothermal energy often serves as a reliable base-load generation source, operating consistently regardless of weather or seasonal variations, setting it apart from other renewable technologies that may experience fluctuations in power output over time (Manzella, 2017) [16].

Geothermal energy extraction processes can be summarized thus:

- Hot high-pressure water is pumped from deep underground through a well.
- When the water reaches the surface, the pressure drops, causing the water to turn into steam.
- The steam spins a turbine, which is connected to a generator that produces electricity.
- The steam cools off in a cooling tower and condenses back to water.
- The cooled water is pumped back into the Earth to begin the process again.

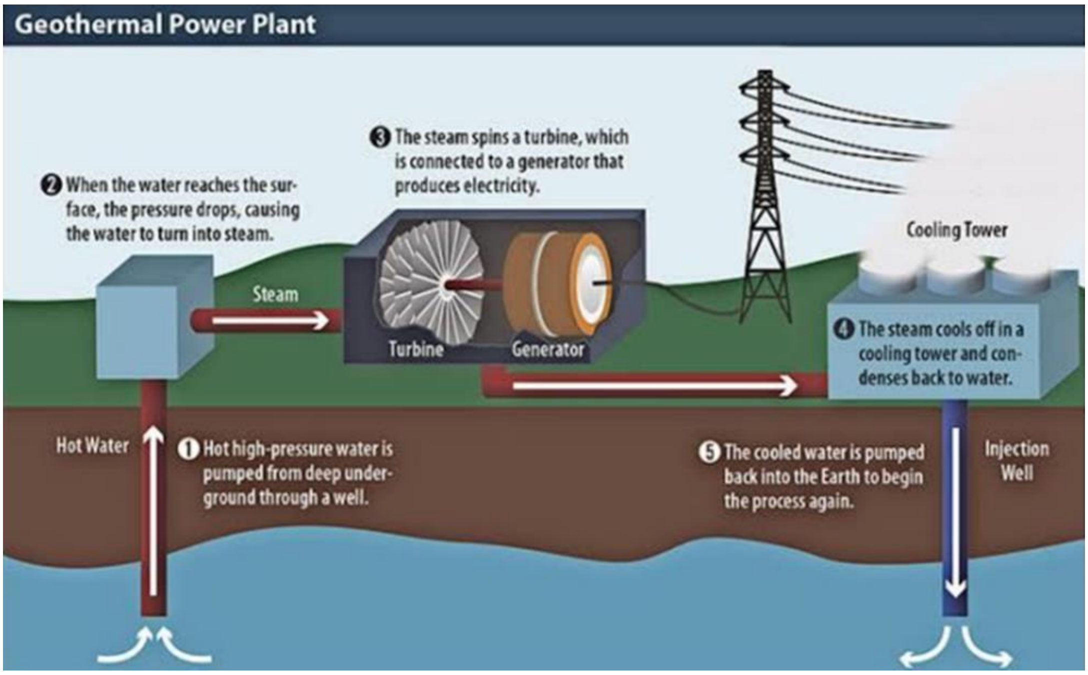

Figure 8 : Operating Processes of A Geothermal Power Plant [16].

I.6 Benefits of geothermalenergy

I.6.1 Advantages of geothermalenergy:

1. A sustainable and reliable system based on the use of natural heat found in the ground.

2. Providing efficient heating and cooling of buildings at low cost.

3. Long service life of 50 years or more.

4. Does not produce harmful emissions to the environment.

5. It is not affected by weather fluctuations.

I.6.2 Disadvantages of geothermalenergy:

1. The installation cost is high at first.

2. You may need a large area of land to install the necessary pipes.

3. It needs regular maintenance to ensure the efficiency of the system.

4. You may encounter installation difficulties in some areas that contain hard rocks or dense soil.

5. Installation may be difficult in existing buildings that do not have an underfloor heating system.

I.6.3 Uses of geothermal energy at the global level

Geothermal energy, one of the most efficient renewable energy sources, is widely used around the world in various sectors to reap its environmental and economic benefits. Geothermal power plants are among the prime examples of harnessing this energy, with the Geysers plant in California, USA, standing as the largest geothermal power station globally. These plants tap into the Earth's internal heat to generate electricity efficiently and cleanly.

Similarly, in Iceland, geothermal heating technology is extensively utilized, where most homes and buildings rely on the Earth's internal heat for building heating and hot water generation. This contributes to reducing dependence on fossil fuels and harmful emissions into the environment [17, 18].

In terms of agricultural applications, geothermal energy is used in some countries to heat agricultural greenhouses, especially during cold winter seasons. This helps increase crop productivity and provides a suitable environment for their growth throughout the year. Additionally, geothermal energy can be utilized in poultry farming, where geothermally heated barns provide a comfortable environment for chickens. This not only helps in maintaining optimal temperatures for the health and well-being of the poultry but also reduces the carbon footprint of the operation.

Not only in agriculture and industry, but geothermal energy can also be used in residential applications. It can be employed for sustainable and efficient home heating, as well as for generating hot water for daily use. This aids in energy conservation and reduces energy bills.

In industry, geothermal heat can be utilized in several industrial processes such as manufacturing, oil refining, and chemical production. This helps in cost reduction and reliance on clean and sustainable energy sources [9].

Despite these widespread uses, there are challenges facing the widespread adoption of geothermal energy, such as the high costs of building power plants and the reliance on geography to identify suitable locations. However, the environmental and economic benefits of this energy make it a sustainable and promising option deserving of further investment and development worldwide [19].

I.6.4 Use of geothermalenergy

- Refresh by geocooling.
- Produceheating.
- Produce domestic hot water (DHW).
- Produce hot and cold.
- Produceelectricity.
- Store heat.

I.7 Geothermalenergy in Algeria :

The geothermal exploration program in Algeria began in 1967 and was completed by the national oil company Sonatrach. In 1982, The National Electric Power Company SONALGAZ conducted geothermal identification studies for the northern and eastern parts of the country in cooperation with the Italian company ENEL. The initial phase of geothermal studies focused mainly on the northeastern part of Algeria. From 1983 onwards, the Wasel Center for Renewable Energy in Algeria (CDER) expanded the program to include the entire northern part of the country [20].

Algeria's exploration of geothermal energy dates back to as early as 1967 when initial studies and surveys were conducted to assess the country's geothermal potential. These early investigations laid the foundation for more comprehensive exploration efforts in later years. The country, situated in a geological zone abundant with ancient volcanoes and seismic activity, has been a favorable location for geothermal energy utilization.

The geothermal exploration efforts in Algeria have evolved over time, with significant developments in understanding the potential and feasibility of harnessing geothermal heat for various applications. Several sites in Algeria, including Dellys in the capital city of Algiers, Adrar, Biskra, and other regions, have seen notable advancements in geothermal power plants [20] [21] .

These geothermal power plants are designed to harness hot water or steam produced from the Earth's geothermal heat. The extracted hot fluids are directed to turbines to generate electricity, contributing to Algeria's renewable energy portfolio. The Algerian government has been supportive of the geothermal energy sector, recognizing its potential contribution to the country's energy mix and part of a broader strategy to diversify energy sources and reduce dependence on fossil fuels[22].

Collaborations with international companies have furthered Algeria's progress in geothermal energy development. These partnerships aim to enhance technology, improve efficiency, and optimize the utilization of geothermal resources in the country.

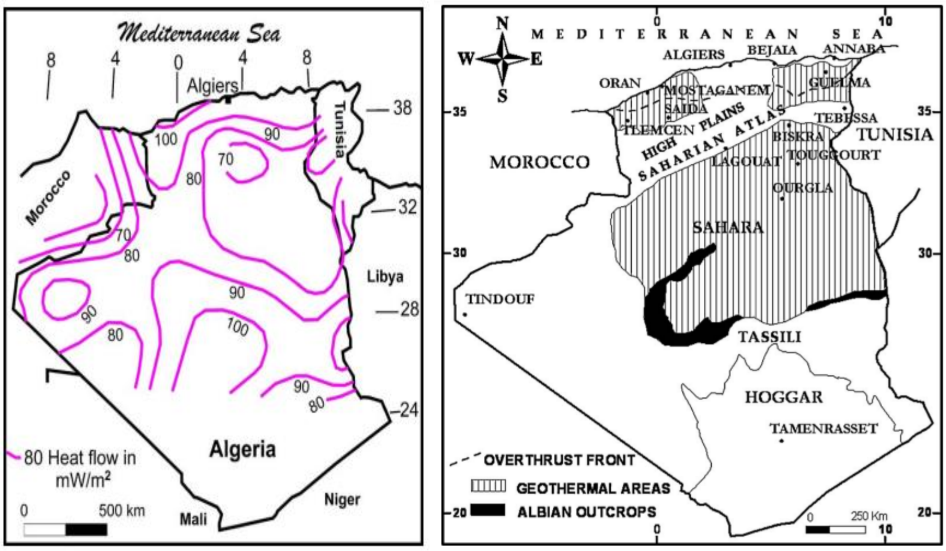

Figure 9 : Map of the main geothermal areas and heat flow of Algeria[22].

I.7.1 Le potentiel des ressources géothermales en Algérie :

Algeria has a strong potential for geothermal energy that can be used for household heating, agriculture, and fish farming. So far, not all geothermal capacities have been fully utilized. The Algerian government now has a new strategy to support renewable energy projects and has recently approved new laws and provided significant financial resources to investors to help them explore and exploit renewable energies for electricity production and other uses. The most important geothermal areas are listed on a new global map (Fig 10) for the entire country, with a very high heat flow in the Sahara geothermal area (90-110 mW/m2). The second high geothermal potential is found in the Eastern geothermal area, in the HammamDebagh thermal spring with a temperature of 98°C. The HammamDebagh locality has been chosen as a pilot project for the establishment of a power plant. A good Enhanced Geothermal System (EGS) is also possible in the Hoggar Shield. The government is now investing in environmental protection by exploring green energies such as geothermal waters to replace fossil oil resources [23].

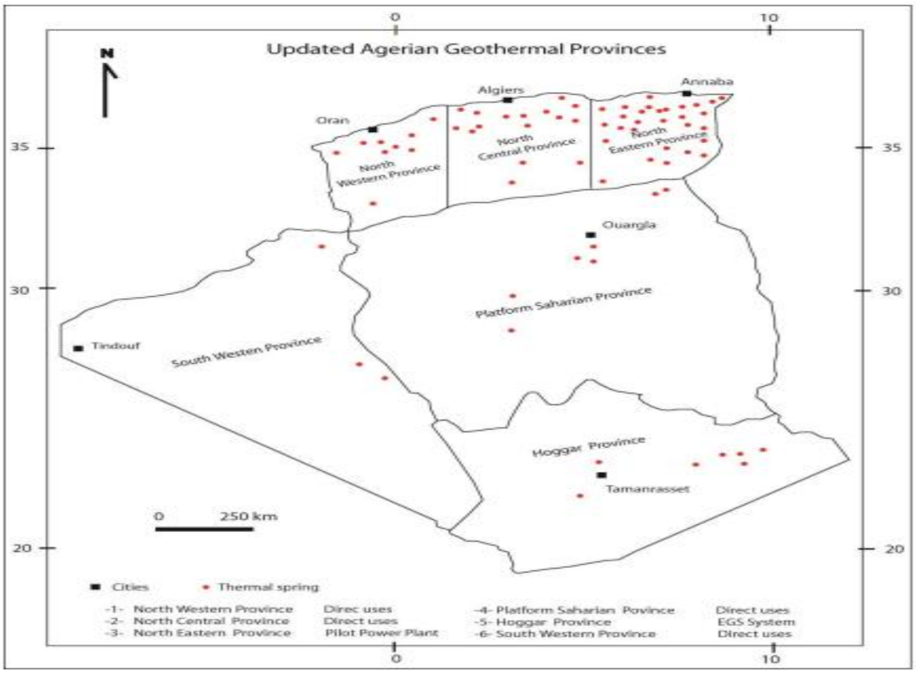

Figure 10 : Principales provinces géothermiques Algériennes [23] .

I.8 Conclusion :

Geothermal energy is characterized by its environmental and economic importance, as it is considered a renewable and sustainable source of energy that plays a vital role in achieving energy independence and protecting the environment. By exploiting heat stored underground, electricity can be generated and heating and cooling systems can be provided in an environmentally friendly and low-cost manner. Geothermal energy applications are diverse and comprehensive, including electricity generation, building heating, cooling systems, and hot water production. Geothermal energy also contributes to enhancing the energy independence of countries, providing job opportunities, and enhancing economic growth. With continued technological development and innovation in the field of geothermal energy, further progress in efficiency and expansion of the use of this valuable energy source can be expected. Thus, geothermal energy remains an important and sustainable option for energy generation and environmental conservation.

CHAPTER 02

Heating technologies for poultry houses

II. : Heating technologies for poultry houses

II.1 Introduction

The design and installation of heating systems in poultry facilities are covered in the article "Heating technologies for poultry houses". These buildings are intended to give domestic birds—such as chickens, ducks, geese, and turkeys—a comfortable place to live in order for them to produce eggs and meat. To maintain the comfort and health of the birds, essential elements include feeding, drinking, resting places, ventilation, heating, and cooling systems. In chicken farming, heat stress is a major problem that impacts the output of both meat and eggs. When temperatures hit 26.7°C or above, hens suffer from heat stress, which can cause problems including excessive panting, slowed growth rates, difficulty hatching, and low-quality eggs. In order to maintain ideal air quality and temperature levels in chicken houses, the text stresses the significance of appropriate air movement and ventilation. The structure's internal air pressure is regulated with the use of circulation fans and negative-pressure air intake pipelines. Technologies for heating are essential for the development, production, and general health of birds.

II.2 poultryhouses

Poultry houses are structures specifically designed to provide a suitable environment for raising domestic birds such as chickens, ducks, geese, and turkeys, with the aim of producing eggs and/or meat. Poultry houses vary in size, design, and materials used in their construction according to the needs of the breeding and the local environmental conditions. Their designs depend on factors such as the region's climate, the desired size of the flock, and the purpose of the breeding, whether for egg production or meat. These structures ensure the protection of poultry from harsh weather conditions such as rain, cold, and extreme heat, as well as protection from pests and diseases. Poultry houses typically include areas for feeding, drinking, and resting, and ventilation, heating, and cooling systems are provided to ensure the birds' comfort and health[24].

Figure 11 :poultryhouses [24].

II.3 Heat stress in chickens

Heat stress is a prevalent issue in poultry farming, especially in both meat and egg production sectors. Chickens experience heat stress when the temperature rises to or above 26.7 ℃, leading them to pant excessively. This can negatively impact their growth rate, hatching ability, egg size, shell quality, and overall egg production. Additionally, high humidity levels in hot conditions can exacerbate the effects of heat stress. It has been observed that heat stress can result in reduced comfort, slower growth rates, poorer feed conversion, and decreased live weight gain in broiler chickens [25].

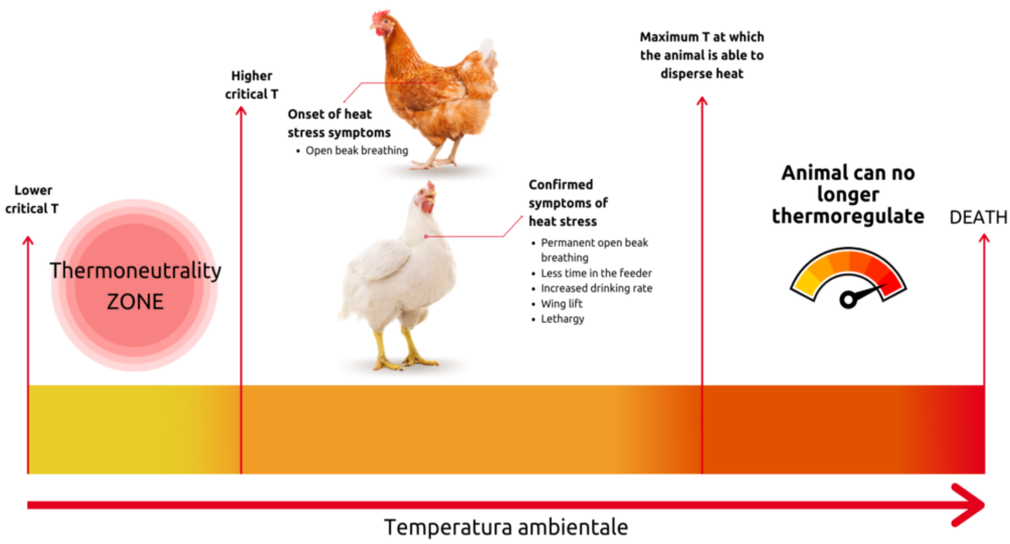

Figure 12 : Heat stress in chicken[25] .

Acute heat stress occurs when birds are rapidly exposed to high temperatures for a brief period, while chronic heat stress results from prolonged exposure to elevated temperatures. Birds housed in open-sided huts commonly used in tropical regions often experience chronic heat stress. This prolonged exposure to high temperatures has been shown to negatively affect the growth and efficiency of broilers, laying hens, and breeders. It can also impair egg quality, meat quality, embryonic development, reproductive performance, immune response, and increase the incidence of illnesses in these birds[25, 26][27].

II.4 Effects of indoor climate conditions on chickens

The indoor climate of chicken housing significantly influences the health, development, and performance of the birds. Below are the key impacts of internal climate conditions on chickens:

II.4.1 Lighting

Early-life lighting has minimal effect on the hormone system in birds; instead, it primarily boosts their activity levels, including feed consumption, growth, and both physical and physiological functions.[28, 29] However, prolonged and intense lighting can lead to issues such as fatigue, cannibalism, immune responses, limb deformities, and potentially mortality[30, 31][32].

The 16 hours of continuous light followed by 8 (h) hours of darkness lighting schedule is commonly used and has been proven to enhance overall chicken performance. However, alternating short periods of light and darkness, known as intermittent illumination, has also been found to improve chicken performance[33, 34] ,[35, 36]. During the posthatch period (1–7 days old), it is recommended to use a continuous lighting program with a minimum light intensity of 20 lux to help chicks adapt to their environment and encourage feeding. Subsequently, the light intensity can be reduced to 3–5 lux, and an intermittent lighting system can be introduced to regulate the birds' activity effectively, leading to improved performance and production[28, 37].

Figure 13**:**poultry house lighting [28].

II.4.2 Air installation

The degradation of bird excrement releases harmful gases like ammonia, carbon dioxide, methane, and hydrogen sulfide, these gases have a negative impact on the health of birds, the cage conditions, poultry facilities, and the environment. As a result, regulating these gases is of paramount importance to successful chicken farming. Suggestions suggest that concentrations of ammonia should be below 25 ppm and that of carbon dioxide should be below 2500 ppm in order to ensure the well-being of birds. Constantly removing the feces from poultry's housing is crucial to reducing the volume of gas produced and maintaining the health of birds[37, 38][39, 40][41, 42][43, 44].

Figure 14 **:**Air installation in poultry houses [39].

In structures that are confined with poultry, but lack sufficient air circulation, the composition of the air can significantly change. The levels of carbon dioxide, ammonia, and other harmful gases can reach hazardous levels. **Table 1** summarizes the critical and ideal concentrations of these gases as documented by research. A ventilation system has a significant role in maintaining air quality by replenishing oxygen, removing toxic gases and smells derived from respiration and the waste process. Additionally, it decreases the concentration of disease-causing microorganisms in the air, which ensures a safe environment for the birds.

Tableau 1: Common gas levels in poultry houses [37].

Gas	Symbol	Lethal	Desirable
Carbon Dioxide	**CO2**	**Above 30%**	**Below 1%**
Methane	**CH4**	**Above 5%**	**Below 1%**
Ammonia	**NH3**	**Above 500 ppm**	**Below 40 ppm**
Hydrogen Sulfide	**H2S**	**Above 500 ppm**	**Below 40 ppm**
Oxygen	**O2**	**Below 6%**	**Above 16%**

To eradicate the excess moisture in your home, you must implement effective ventilation. This not only decreases the humidity relative to the air, but also increases health and prevents the buildup of moisture on the walls and ceilings. As the temperature increases, the air volume increases, which enables it to hold more water. A simple 20 degree increase in temperature increases the humidity's capacity to be retained in the air.

II.4.3 Air velocity

Varying the air flow rate within the chicken coop can partially address high internal temperatures. Additionally, the velocity of the air is of paramount importance in the process of cooling and maintaining air quality[39, 45]. For temperate climates, a ventilation capacity of at least "5 m^3per chicken per hour" is recommended, with average inlets of 1.5 cm^2 per m^3 of ventilation[37]. When temperatures are between 25 and 30 ℃ (degrees Celsius), the still air velocity (0.1–0.2 m/s) can be maintained, as proposed by Hulzebosch. However, Lacy and Czarick observed that broilers had a higher growth rate at 2 and 3 m/sair velocity, respectively, when the same temperature was maintained[42, 44].

Research conducted on chickens aged between 4 and 6 weeks within the temperature range of 25–30 ℃ and varied air velocity aimed to elucidate the impact of air velocity on the birds. The findings indicated that increased air velocity of 2 and 3 m/s benefited 6-week-old broilers more than their 4-week-old counterparts. This difference may be attributed to the higher warmth requirements of younger birds during the brooding period.

II.4.4 Humidity

Oloyo observed that when the internal temperature was over 26.7 ℃, combined with a high relative humidity, there was a significant decrease in the efficiency of feed usage, feathering, pigmentation, and weight gain in chickens[29, 38]. Additionally, regardless of the relative humidity's changes, the birds have a lower performance within the internal temperature range of 35-37.8 ℃. This suggests that higher humidity may facilitate bird performance at lower temperatures. However, it's essential to regulate the humidity, as it could promote a favorable environment for microbes, which could put the birds in danger[39, 46].

Temperature and relative humidity are closely intertwined factors. During the brooding period, especially in the early weeks, internal relative humidity may be low or excessively low due to the heat required by the chicks at that age or when they are thirsty or hatched in warmer conditions. The evaporative cooling process of chickens as they grow releases water vapor, causing internal relative humidity to increase rapidly[37]. Consequently, regardless of the bird type, the third week and beyond are crucial stages in chicken production.

For optimal success, laying birds, as per Oloyo, require relative humidity levels of 60–80 percent during brooding and 50–70 percent post-brooding[38].

II.4.5 Temperature

Determining the optimal temperature range for different types and age groups of chickens is still a controversial topic, which is probably influenced by environmental factors like humidity and wind speed, these factors affect the temperature of the chickens and their responses. Despite the breed or age (broiler, pullet, or breeder), chickens typically have a wide tolerance of temperatures. However, the exposure of chickens to high temperatures has been demonstrated to negatively affect their production performance, particularly when combined with high humidity, this combination is detrimental to evaporative cooling[38, 47].

For young chicks that are day old, Ketelaars[37] advised maintaining a temperature of 30-32 ℃ at the height of chicken. Later, the temperature should decrease by 3-4 ℃ over the course of a week or so until the chicks have reached 4 weeks of age. Daghir reported that growing chickens need a temperature range of 18-22 ℃ . Holik documented in previous reviews that birds have the greatest comfort when the temperature is between 18 and 24 ℃. However, the optimal level of performance achieved by chickens is ultimately determined by the value of the product in comparison to the cost of feed[29, 48].

The table below represents (Table 3) the recommended temperature for poultry farming in the El-Oued area.

Tableau 2 : Recommanded température Schedule [29].

Age of Chicken (Week)	**Temperature Range (°C)**
1	**30-32**
2	**30-26**
3	**26-23**
4	**23-20**
5	**20**

Ensuring optimal production temperatures in tropical climates is challenging and requires poultry houses to pay close attention to temperature fluctuations.

II.5 Poultryhousing system

The fowl house system plays an important role in the production of chickens. The fowl house provides a comfortable environment for the hens, isolating them from the harsh external environment that could harm their health and productivity. In a chicken house, the total heat produced is the sum of the heat produced by the birds, the surroundings, and the bio-decomposition of feces [49, 50]. Thus, the type of house chosen has a strong influence on the management approach. The impact of two open dwelling systems which are applicable in tropical regions has been investigated in our study: naturally ventilated and mechanically ventilated.

II.5.1 Naturally ventilated open housing system

The open poultry housing system is linked to tropical regions due to its affordability, ease of use, and capacity to control heat generation inside buildings through natural ventilation [45, 47, 51]. Nevertheless, it is prone to bugs. Rodents, birds, and other small predators can all have a detrimental effect on the performance, productivity, and general well-being of chickens. Dwarf sidewalls are raised to the roof eaves and covered in corrugated wire mesh to deter predators in order to address this problem. To further guard against bug infestation, a gutter surrounding the house is treated with pesticides. The following section discusses design factors to take into account while building an open poultry house to maximize chicken performance and production.

II.5.2 Construction direction

To reduce sidewall exposure to direct sun radiation, the chicken coop should be orientated east-wes. This is important because direct sun radiation exposure can exacerbate heat stress in birds. While deep litter raising does enable the birds to stay out of the sun; this could lead to a concentration of birds in one area of the house. Cooling becomes challenging as a result, which may cause stampedes or even death [45, 50].

II.5.3 Width, length and height of the house

The benefits of predominant east or west breezes may be diminished by the east-west orientation of a chicken coop. Consequently, Daghir[45]suggested that in order to prevent this issue, the building's breadth not exceed 12 m. Moreover, the problem of an uneven air exchange the building's temperature and rate are stable.

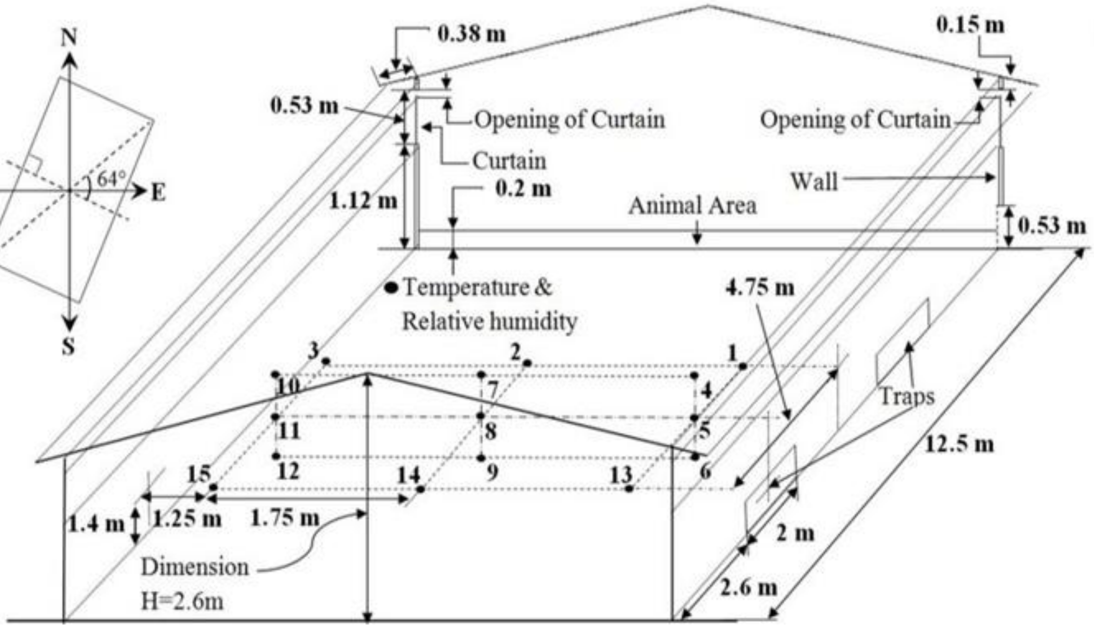

Figure 15 **:** Dimensions and location of the poultry barn building [45] .

Moreover, the services and activities provided by experts and chicken farmers within the facility must be included in the design. These tasks could involve moving chickens, feeding them, plucking them, managing waste, immunizing them, and other tasks. Consequently,

Longer pen houses may be difficult to maintain, particularly if the tasks are done by hand. Doors can be positioned every (15 to 30) m to provide simple service delivery and circulation [45].Qureshi[47]suggested that it's a good idea to consider how many layers will be employed while designing battery cages. Two-tiered cage arrangement . It allows for simple air exchange within the structure, and the cage is composed of three or four levels ;There can be an issue with air exchange in the system. As a result, it is advised that rows there can only be three cages total, and the center passageways must be at least 1.2 m long. There can only be a height differential of one meter from the ceiling.

II.5.4 Sidewallopenings

The sidewall is constructed up to the roof eave and consists of a movable curtain and a permeable membrane, such as corrugated wire mesh. A minimum height of 0.4 m is advised to protect the house from water seepage, direct and indirect sun radiation, pests, and predators [52]. Easy ventilation is made possible by the corrugated wire mesh on both air velocity and flow are managed by the movable curtain both within and outside the structure. The curtain may be translucent or have varying colors to aid in the management of sporadic lighting schemes [29, 45].

Figure 16**:**Poultry sidewall inlets - wall vent poultry house ventilation [45].

II.5.5 Roof slope

It was advised to have a 45° degree roof slope because it decreases the amount of heat that the roof absorbs from direct sunlight, extends the distance between the bird and the heat that builds up beneath the roof, and facilitates the rapid evacuation of the heat that builds up beneath the roof. the roof through the ridge aperture, creates open space above for equipment installation, and expands air space to enhance air exchange rate [45],[50]. On the other side, the quality of the insulation dictates the slope of an insulated roof.

II.5.6 Roof overhang

Building sidewalls can be shielded from direct and indirect solar radiation by using roof overhang. Conversely, the height of the sidewalls dictates the length of the roof overhang [52]. shade from the roof overhang, When positioned correctly, with a 45° roof slope [50], sidewall heat absorption may be reduced by about 30%.

II.5.7 Ridgeopening

Hot air naturally rises over colder air due to differences in air density. By producing a stack effect, installing ridge apertures in the chicken house can aid in ventilation. In order to prevent inadequate circulation and ventilation, suitable Building setbacks are crucial [51, 52]. However, it has been demonstrated that ridge opening is ineffective in insulated chicken houses due to the constant temperature inside the building .

II.5.8 Obstructing construction

A suitable distance between buildings is necessary to prevent inadequate air exchange rates in buildings. When deciding on the ideal housing spacing, topography, wind direction, and speed are all crucial variables to take into account. But the formula for calculating the distance between buildings is given below [52].

$$\mathbf{D = 0.4. H. L. 0.5} \qquad \textbf{(1)}$$

Where $\boldsymbol{D}$ is the dwelling spacing (the next house's closest wall's ridge).

$\boldsymbol{H}$ **:** is the building's adjacent height.

$\boldsymbol{L}$**:** the neighboring building's length.

To lessen the number of wild bird nests and the invasion of rats and other predators, vegetation should be maintained to a minimum and at an average height. Moreover, tree branches should be maintained at eaves level to avoid obstructing airflow throughout the house[52].

II.5.9 Roof, end-wall and sidewall insulation

Tropical farmers have effectively constructed naturally ventilated chicken houses with locally obtained materials, such as bamboo and thatched roofing [47].

In poultry houses that are naturally ventilated, the minimum recommended Rvalue for ceiling insulation is 1.25 $m^2 C/W$. A minimum R-value of 2.25 $m^2 C/W$ is required for temperatures over 40°C[52] .There are several ways to insulate a chicken house ceiling:

spray polyurethane insulation, rigid board insulation, drop ceiling, and reflective insulation.

II.5.10 Cooling system

It has been demonstrated that rooftop sprinklers greatly reduce roof temperature [45, 50]. But in this case, the preferred material needs to be resistant to repeated exposure to water [52]. A fogging device can be used to lessen evaporative birds' ability to cool off in hot conditions. Birds benefit from the high water pressure mist it produces to keep cool. However, as high temperatures can be detrimental to birds' health, the humidity level in the house needs to be managed[45, 50].Through the promotion of convection cooling and increased air velocity, a circulation fan lessens heat stress. Generally speaking, circulation fans cover an area that is 15 times the horizontal diameter by 5 times the vertical diameter and generate air velocity of at least 0.5 m/s.

diameter [45], For best circulation fan use, it should also be positioned between one and 1.5 $m$above the floor and slanted downward at a 5° .

II.5.11 Vegetation

Shrubs and grasses use shade and convection cooling to reduce direct and reflected solar radiation [50]. Vegetation needs to be cut and kept clean to deter pests and predators [52].Planting tall trees beside the edges can serve as a canopy, which during the hottest hours of the day protects the sidewalls from direct sunlight or reflects it.

II.6 Open housing system with mechanical ventilation

The incapacity to maintain suitable interior environmental conditions required for optimal bird performance during severe weather conditions led to the installation of a mechanically ventilated housing system. Furthermore, mechanical Increased control over air exchange, wind direction, and wind velocity is made possible by ventilation [37]. Mechanically ventilated systems use either positive or negative pressure systems. The most common negative-pressure system in mechanically ventilated homes uses fans to force air out of the structure through an air inlet system, which lowers the internal pressure and lets in fresh air through the same air inlet system [52].

Negative-pressure systems can be created via tunnel or inlet ventilation. While tunnel ventilation has intake pipes on one end and exhaust fans on the other, inlet ventilation equally distributes air inlets and exhaust fans throughout the house. This increases air speed, which produces greater positive air exchange and improves tunnel ventilation [52].

II.6.1 Building a poultryhouses

Housing is a crucial component of chicken farming, and producers frequently have questions about how to construct a poultry house. Basically, the primary method for maintaining your birds' health, rapid growth, and maximum productivity is their housing [45]. For the best ventilation control, the house needs to be solidly constructed and adequately insulated [52]. Instead of a complete wall, the sidewall can be equipped with movable, insulated curtains that can be used in the winter or in the event of a power outage. It's important to remember that stationary curtains don't insulate as well as solid walls do.

Concrete should make up the floor, and it should be dry and rat-proof. The floor of the house should be 1.5 feet beyond the wall on both sides to prevent issues with rats and snakes. For deep-litter chicken houses, the door needs to be left open. outdoors. The door must measure a minimum of 6 by 2.5 feet .Figure 17 , [53] illustrates the geometric and structural shape of poultry homes.

Here are some fundamental details for creating a sturdy system for housing poultry:

- There needs to be adequate ventilation in the chicken house.
- Make sure there is enough natural light and airflow entering the home.
- Orienting the house to face north to south will be preferable.
- If you build multiple dwellings, the appropriate spacing between them is roughly $12m$
- Before storing the birds inside the poultry house, thoroughly clean the home.
- Create a deep liter and ensure it is always clean and dry.
- Maintain the appropriate spacing between feed and feeding apparatus within the chicken house based on the quantity and demand for poultry birds.
- It would be preferable if you could construct the home outside [53].

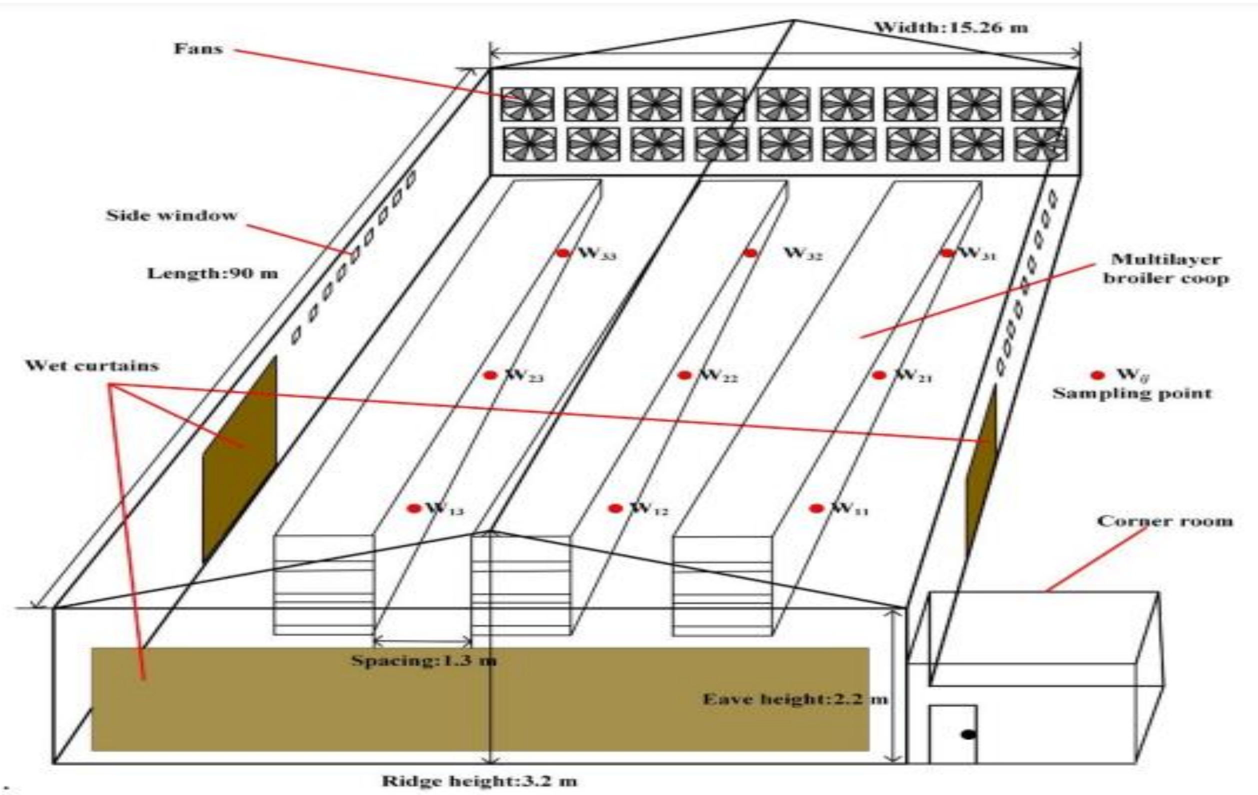

Figure 17 **:**Poultry house design [53].

II.6.2 Air exchange

The heat produced by the activity inside the chicken house and the high outside temperature enhance the temperature of the air inside. To maintain the indoor air quality, an effective mechanical ventilation system needs to exchange air quickly. temperature that is within 2.8 °C of the ambient temperature outside. To calculate the size of exhaust fan required for adequate ventilation, apply the formula below [52].

$$\mathbf{Buildingsurfaceheat(watts)} = (\boldsymbol{A}/\boldsymbol{R}) \times (\boldsymbol{T_o} - \boldsymbol{T_i})(2)$$

Where A: is the building surface area (in meters squared).

R :is the insulation value ($m^2\ C/W$) of the wall material.

T_o :temperature outside (°C); T_i Temperature inside (°C)

This is the highest outside temperature that is independent of the surrounding surroundings. But when figuring out how much heat a roof in a house with an attic gets, the To value for ceilings that have insulation right underneath the roof isregarded as 65 °C[52]. Ti should be regarded as 27°C to ensure the comfort of birds. R is the total of the wall segment's insulation values added together.

While broiler, pullets, and broiler breeders produce 5.1$W/Kg$of total heat production (sensible and latent), commercial broilers produce 7.9 W/Kg[52, 53]. Below is an expression of the heat produced by birds :

$$\boldsymbol{Birdheat(W) = sensibleheat(W/Kg) \times weightofthebird(Kg)} \quad \textbf{(2)}$$

Sensible heat accounts for half of the total heat generated by birds.

$$\boldsymbol{Totalheat(W) = buildingsurfaceheat(W) + birdheat(W)} \quad \textbf{(3)}$$

On the other hand, the air movement capacity needed to keep the intake and exhaust air at a temperature differential of 2.8 °C is displayed below.

$$\boldsymbol{Air\ capacity(m^3/h) = total\ heat(W) \times 3 \cdot 4/2 \cdot 8}\ ^\circ\mathrm{C} \quad \textbf{\textit{(4)}}$$

II.6.3 system of air intake

As a result of the air being drawn out of the barn, negative air pressure builds inside the structure, causing outside air to automatically rush through designated openings and into the barn. The rate at which this air rushes in is determined by the quantity and speed of air being drawn out.By controlling the position, speed, and direction of fresh air introduction, negative-pressure air intake pipes are utilized to modify the internal climate. Conversely, the exhaust fan regulates the amount of air that enters the house. In Figure 8, the most common system is shown graphically. The exhaust fan(s) in air can enter Barn through specially built entrances because of the tiny negative pressure or vacuum created by the hen house[52].

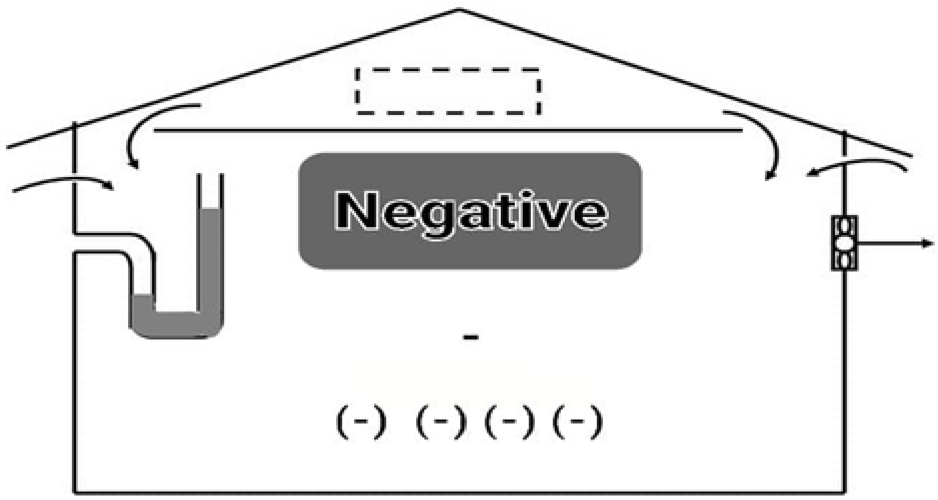

Figure 18**:**Air intake pipes with negative pressure [52].

II.6.4 Speed of the inlet

The pressure difference between the inside and external environments controls the fresh air admission speed [52]. On the other hand, the number and dimensions of air inlets control the pressure. Due to the simplicity with which differential pressure can be managed, including the building's internal airflow pattern and the negative-pressure air entry pipes that regulate the interior climate.

II.6.5 Region of the inlet

Static pressure of between 12 and 25 Pa must be produced by the exhaust fan in order to easily manage and distribute air throughout the chicken coop[52].

II.6.6 Control of the air intake

The air intake design should be set carefully since the direction of air depends on the age, chicken class, and external climate. Air inlets should be constructed to direct air toward the ceiling during the colder months of the year, but during the air flow should be directed toward the floor during the warmer months of the year [45].

The regulation of the air inflow for poultry houses is shown in Figure 19.

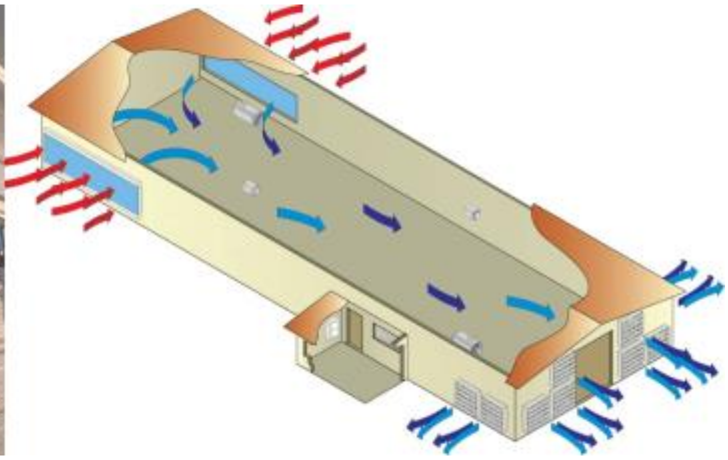

Figure 19 **:**Control of the air intake in chicken houses [45].

II.6.7 Types of inlet ventilation system

II.6.7.1 Cross ventilation

The air intake pipes are located on one side of the poultry house, while the exhaust fans are located on the other. Small chicken houses (less than 10 m) are a good fit for it since it alters the ambient conditions in larger homes [52].

II.6.7.2 Ventilation through the sidewall

Underneath the air intake pipes on both sides of the building walls are exhaust fans. Nonetheless, there should be a minimum of twice the fan diameter between the exhaust fans and the air intake pipes. Air is drawn through the floor by the exhaust fans, which are directed toward the center. It's also suitable for homes having a maximum of 12 meters in width [52].

II.6.7.3 Attic entrance for ventilation

Air intakes are located in the ceiling, and exhaust fans are located on the bottom sides. This kind of ventilation works best in hot areas and requires enough insulation in the ceiling. The ventilation strategy is strongly advised for growing laying hens [52].

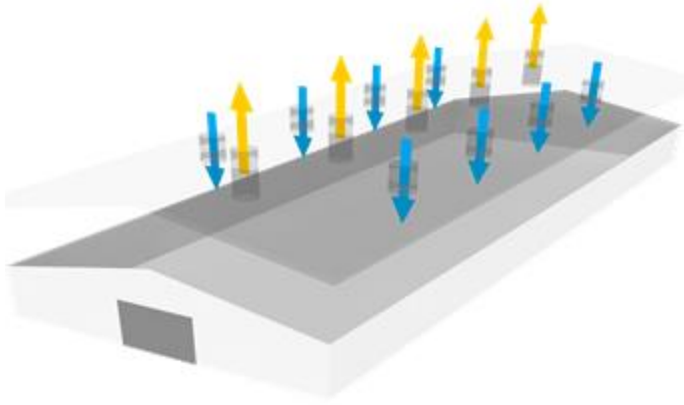

Figure 20 **:**The poultry house's overhead ventilation [52].

II.6.7.4 Air movement inlet for ventilated house

Through the air intake pipes, fresh air enters at a speed of 3.5–6 m/s; however, depending on the size and style of the residence, this speed quickly lowers to about 1 m/s. To guarantee there is enough air, circulation fans are used to accelerate air speed. flow inside the structure [52].

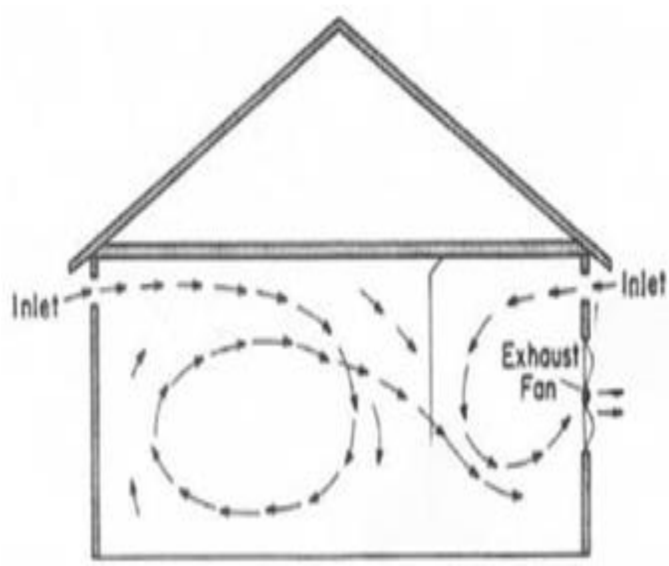

Figure 21 **:**The poultry house's internal airflow[52].

II.6.7.5 Tunnel ventilation system

The air velocity and exchange rate needed are maintained by the tunnel ventilation system's design. Conversely, the kind of bird involved dictates the required air velocity. The recommended air speed for raising different kinds of chickens and birds exhibited in Table 4[52].

Tableau 3 :Air velocityrecommendations for tunnel-ventilateddwellings[52].

House Type	Air Speed (m/s)
Broilers	2.5–3
Pullets	1.75–2.25
Broiler Breeders	2.25–3
Commercial Layers	2.5–3

II.6.7.6 Tunnel fan capacity and air speed

The process used to establish the input ventilation system's capacity is also used to determine the tunnel fan's capacity. The required average air velocity within the entrance ventilation system is different from that of the system that uses a circulating fan to maintain an appropriate air velocity. The following formula is used to calculate tunnel house[52].

$$\boldsymbol{Airvelocity} = \frac{\boldsymbol{tunnelfancapacity}}{\boldsymbol{cross{-}sectionalareaofthehouse}} \times \mathbf{3600} \qquad (5)$$

where tunnel fan capacity, m^3 /h; cross section area, m^2; and air velocity, m/s

It's important to remember, nevertheless, that the cross sectional area of the house has an adverse effect on internal air velocity. Consequently, long, narrow homes with low ceilings are advised [52].

Therefore, it is possible to use the following statement to create the necessary air speed

$$\boldsymbol{Tunnelfancapacity} = \frac{\boldsymbol{desiredairvelocity}}{\boldsymbol{cross{-}sectionalareaofthehouse}} \times \mathbf{3600} (6)$$

where the cross section size, m^2,the desired air velocity, m/s, and the tunnel fan capacity, m^3/h

Large cross-sectional area air deflectors can be used to reduce the cross-sectional area within the chicken house when room is at a premium. Drapes that extend 2.5–3 m from the ceiling to the floor are known as air deflectors. Research demonstrates that air deflectors increase air velocity across a 1.2- and 6- to 9-m upwind and downwind distance, respectively. But in order to prevent increasing static pressure and disrupting fan performance and air exchange rate, the air deflector needs to be positioned at least 2.5 m above the ground [52].

II.6.7.7 Air velocity distribution

It is generally accepted that the air velocity in a tunnel home is constant throughout. However, it changes a little bit based on additional air-deflecting obstacles, poultry gear, and how smooth the building surfaces are. The difference in There could be a 15% to 40% difference in air velocity between the sides and the center of the home [45].

II.6.8 Types of Poultry Exhaust Fans :

- Mounted on the wall exhaust fans Designed to remove moisture and stale air from the structure, these fans are usually fixed on the walls of chicken houses.

- Exhaust fans positioned on ceilings These are used to ventilate poultry buildings and remove extra heat and humidity. They are fixed on the ceiling.

- Box fans These are small, transportable fans that can be positioned throughout a chicken coop to provide it more ventilation and air movement.

- Cone exhaust fans Usually mounted on the roof of poultry houses, these fans are made to expel hot air and smells from the facility while also providing high-volume airflow.

- Tunnel ventilation fans Air is carried across the length of the building to offer ventilation and cooling for poultry using tunnel ventilation systems.

II.7 Conclusion :

The text emphasizes the importance of effective heating methods in poultry farming for optimal environmental conditions. Proper ventilation systems control temperature and air quality, reducing heat stress on hens. Air intake devices and circulation fans maintain appropriate airflow, reducing heat stress risks, ensuring optimal indoor climates, and enhancing bird health and productivity.

The article goes on to describe other heating techniques that go into creating and maintaining a well-maintained system for keeping chickens:

- Radiant heaters :These heaters directly heat surfaces and objects in the poultry house by emitting infrared radiation, giving the birds a steady and comfortable source of heat.
- Forced-air heaters: These heaters assure uniform heating and maintain a constant temperature by using a fan to distribute hot air throughout the poultry house.
- Gas heaters: These economical heating options for poultry houses run on natural gas or propane.
- Electric heaters: These heaters use electricity to provide heat and are frequently used as additional heating in bigger facilities or in smaller poultry houses.
- Biomass heaters: Using maize, wood pellets, or other agricultural byproducts as fuel, biomass heaters provide a sustainable and renewable heating solution for chicken coops.

Poultry farmers may achieve efficient production outcomes by putting these heating solutions into place and maintaining housing systems that promote the best possible health and productivity for their flocks.

CHAPTER 03

The effect of geothemal energy on the internal environment of the poultry houses

III. :The effect of geothemal energy on the internal environment of the poultry houses

III.1 Introduction :

The identification of traditional and modern poultry farmers can be based on several key factors:

1. **Infrastructure and Facilities:**

Traditional poultry farmers typically have basic infrastructure and facilities for housing chickens, such as simple shelters or coops.

Modern poultry farmers have advanced facilities with climate control systems, automated feeding and watering systems, and specialized lighting for optimal growth and production.

2. **Technology and Equipment:**

Traditional poultry farmers rely on manual labor and basic tools for tasks such as feeding, watering, and cleaning.

Modern poultry farmers use advanced technology and equipment such as incubators, automatic feeders, and ventilation systems to optimize production efficiency.

3. **Breeding and Genetics:**

Traditional poultry farmers may use traditional breeding methods and may not have access to high-quality breeding stock.

Modern poultry farmers use modern breeding techniques, genetic selection, and high-quality breeding stock to produce healthier and more productive chickens.

4. **Feed and Nutrition:**

Traditional poultry farmers may use traditional feed sources and may not have access to specialized poultry feed.

Modern poultry farmers use high-quality, specialized feed formulations to meet the nutritional needs of their chickens and optimize growth and production.

5. **Management Practices:**

Traditional poultry farmers may rely on traditional management practices passed down through generations.

Modern poultry farmers implement best practices in poultry management, biosecurity measures, and disease prevention to ensure the health and well-being of their flock.

Overall, the identification of traditional and modern poultry farmers is based on the level of technology, infrastructure, breeding practices, nutrition, and management techniques used in their poultry farming operations. Modern poultry farmers tend to have higher productivity, better quality products, and improved efficiency compared to traditional farmers.

III.2 Materials and methods

chicken farmers may efficiently employ geothermal energy to offer their chicken houses with sustainable heating and cooling solutions by using these materials and techniques, which will save energy and have a less negative impact on the environment.

III.2.1 Site selection, excavation and installation

The installation and drilling of a geothermal heat pump system in poultry houses involves placing the loop heat exchanger underground. This process ensures optimal performance and long-term durability. The site selection is crucial, influenced by factors like groundwater levels, topography, and soil properties. Careful site selection maximizes the benefits of geography and geology for efficient heat exchange, making it a vital step in the geothermal heat pump system installation process[54].

The drilling procedure begins with the identification of the location, which may involve digging wells or trenches to accommodate heat transfer fluid pipes. The drilling operation is meticulously planned to ensure uniformity and straightness in the route. After the drilling, the heat exchange loop is installed, ensuring effective heat exchange by expertly connecting flexible or rigid pipes. Geological and environmental factors are considered during the installation process to ensure the system's sustainability and lifespan [55].

Essential tests are conducted to confirm the system's integrity and heat exchange loop's operation, including pressure, leakage, and flow tests, to ensure smooth operation and ensure long-term safety and effectiveness. These procedures are meticulously followed to ensure long-term success.

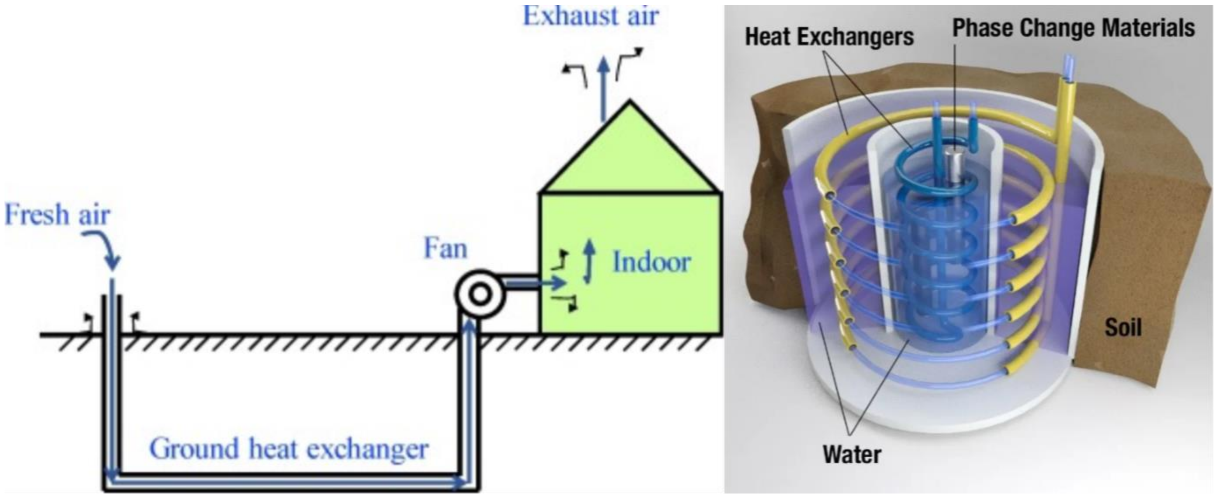

Figure 22. Geothermal installation[55].

III.2.2 Design of a Geothermal Heat Pump System

Efficient heating and cooling of chicken houses requires the design of a ground source heat pump(GSHP) system that meets their needs. This entails setting up the heat exchange loop for heat exchange, figuring out the required pump capacity, and designing the ideal distribution system to guarantee uniform heat distribution throughout the building. Poultry houses can have more pleasant temperatures while using less energy when a well-designed system is in place[56, 57] ,[58].

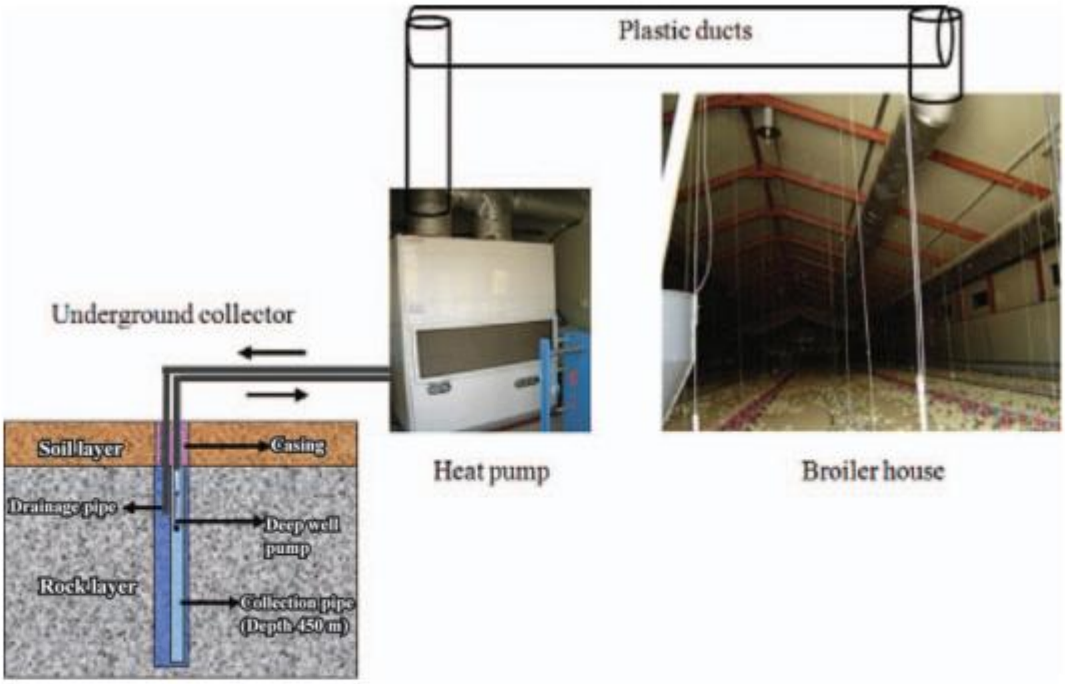

Figure 23 **:** Ground source heat pump in poultry house[58] .

III.2.3 Working of a HeatPump

By generating a temperature differential between the earth and the air, a revolving heat pump system is utilized to heat or cool buildings. There are two units in total: an indoor unit and an outdoor unit. It moves heat from the ground cooling system to the internal power unit in the winter and from the interior unit to the floor in the summer.

A structure's coolant is transferred in alternate cycles through subterranean pipes, acting as a source of cooling in the summer and winter. By controlling these functions, control units make sure the suit stays at the right temperature. This process is controlled by the heat pump, which pumps coolant as needed.

Critical factors such as exterior and ground temperatures must be taken into consideration when using, installing, and maintaining the heat pump[59, 60].

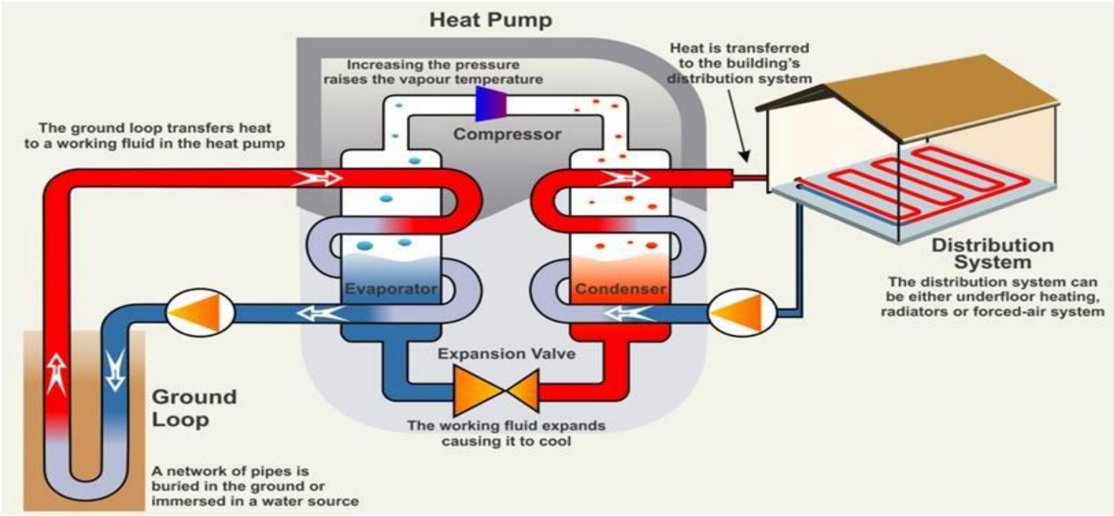

Figure 24 **:**Basic operating principle of a ground sourced heat pump (GSHP)[60]**.**

III.2.4 Fluid for Heat Transfer

choosing a suitable heat-transfer fluid (such as water or antifreeze solution) to move heat between the earth and the heat pump system via the ground loop.

III.2.5 Surveillance and maintenance

System performance should be routinely monitored to guarantee optimum efficiency and functionality. Maintaining the heat pump unit may involve servicing it as necessary, checking fluid levels, and looking for leaks in the pipes.

III.3 The difference between modern poultry houses and traditional poultry houses :

Traditional poultry farmers typically rely on older, more basic methods of raising chickens. They may use simple shelters or coops for housing, and may not have access to modern technology such as heating, ventilation, air conditioning, and lighting in their facilities. These farmers may also use more traditional feed and breeding methods.

In contrast, modern poultry farmers utilize advanced technology and equipment in their operations. They may have climate-controlled facilities with automated systems for regulating temperature, humidity, and ventilation. They may also use specialized lighting to simulate natural daylight and promote optimal growth and egg production. Additionally, modern poultry farmers often use high-quality feed and breeding techniques to produce healthier and more productive chickens.

Overall, the identification of traditional and modern poultry farmers lies in the methods and technology they use in their operations. Modern poultry farmers tend to have higher productivity and produce better quality poultry products compared to traditional farmers.

III.3.1 The location of the poultry house where the study was carried out :

The study state is located in the southeast of the country at a distance of 670 km from the capital, Algiers. It lies between latitudes 33° and 34° north and longitudes 6° and 8° east. It belongs to the northern desert of the eastern race, where the study was at the level of the municipality of **Oued El-Rguiba.**

Its limits :

- Biskra and Tebessa in the north.
- Djelfa State in the northwest.
- Ouargla state in the south and southwest.
- The Tunisian border from the east

Figure 25 : Represents pictures of the poultry house we studied.

III.3.2 Effect of natural conditions on poultry houses (without geothermal energy(Traditional poultry farmer.)

III.3.2.1 Air

III.3.2.1.a The natural flow of air

As the name suggests, natural ventilation is a technique that leverages the forces of nature to supply poultry facilities with fresh air. Through the structure's inputs and outputs, air is exchanged. Understanding the distinctions between natural and mechanical air conditioning systems. Air exchange fans in mechanical ventilation systems can be adjusted to produce the necessary air exchange rate. The weather can change suddenly and effect both wind and thermal buoyancy. This is how natural ventilation control is identified [24]. Tell us how it operates in "open-air buildings," "landscape buildings," or "natural buildings." It is possible to use ventilators inside the building to allow air to circulate. In Figure 26.

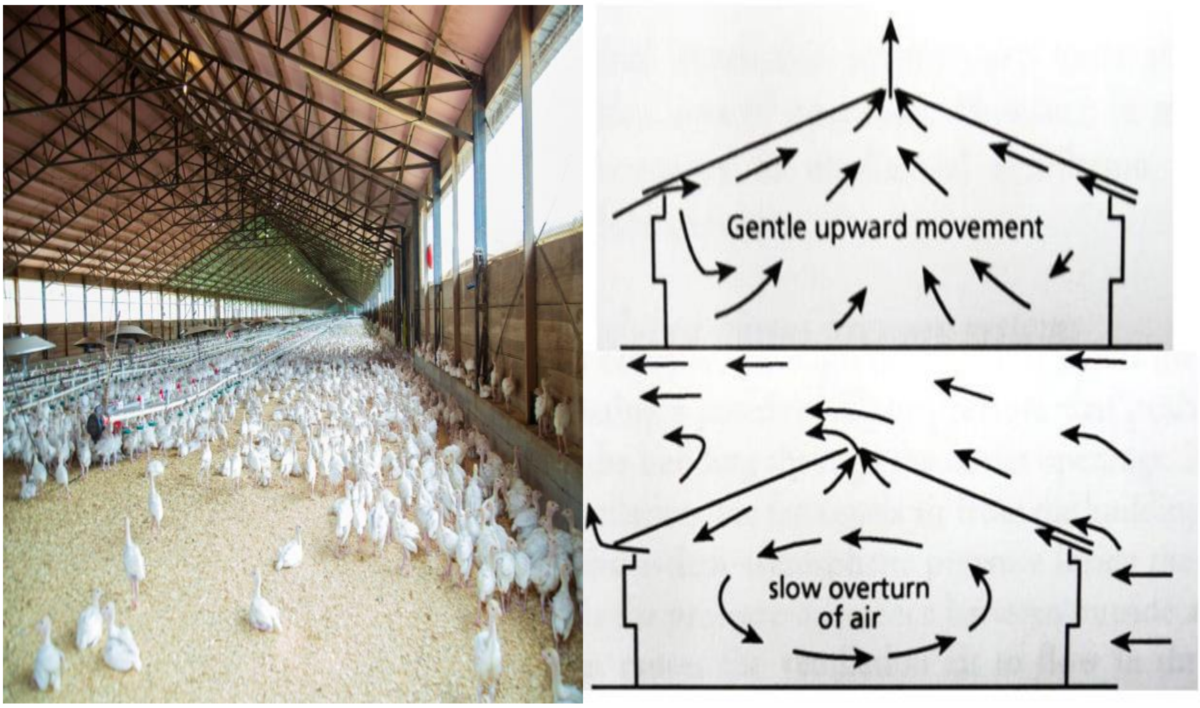

Figure 26 **:**Natural Ventilation[24]**.**

III.3.2.1.b Air caliber

Air is composed of nitrogen, oxygen, carbon dioxide, water vapor, and minute amounts of other gases. Water vapor contributes less than 1% of the total, yet it has a big impact on how the air mixture is defined. This is because water is so important to the life cycle in addition to its high vapor form energy content. Of all common liquids, water vapor has the highest latent heat (the energy in the form of heat required to change water from liquid to vapor). Because of this, the majority of the combined heat energy in an air mixture is often derived from the small amount of water vapor present in the mixture. When permitted to build up to levels above reasonable thresholds, air The chicken house's air quality is compromised by pollutants. Solid particles, microorganisms including fungi, bacteria, and viruses, and gasses like carbon dioxide, hydrogen sulfide, and ammonia are examples of contaminants. The air in poultry houses is always somewhat contaminated, but with a well-managed system, the amount can be reduced.

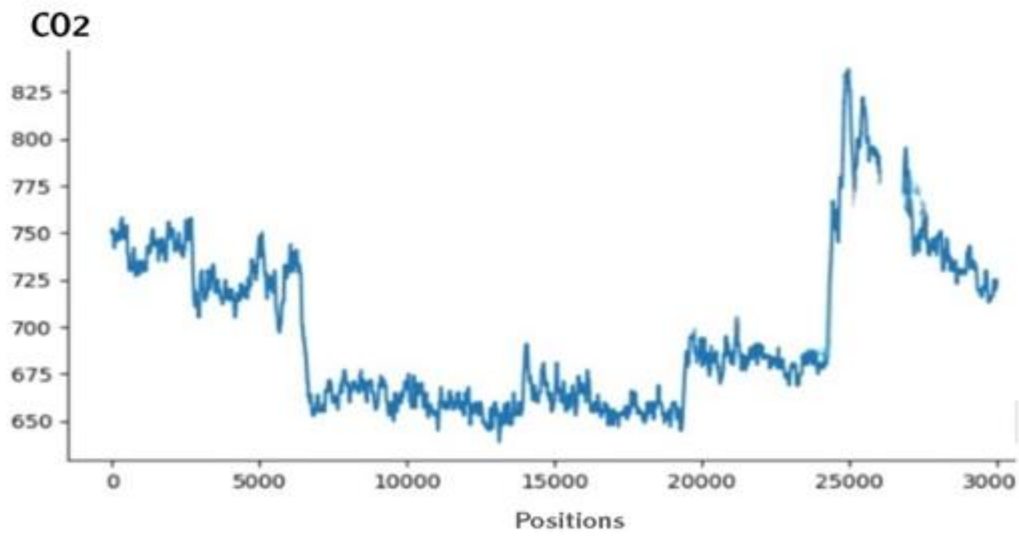

Figure 27 :Shows air CO2 changes in the Traditional poultry house .

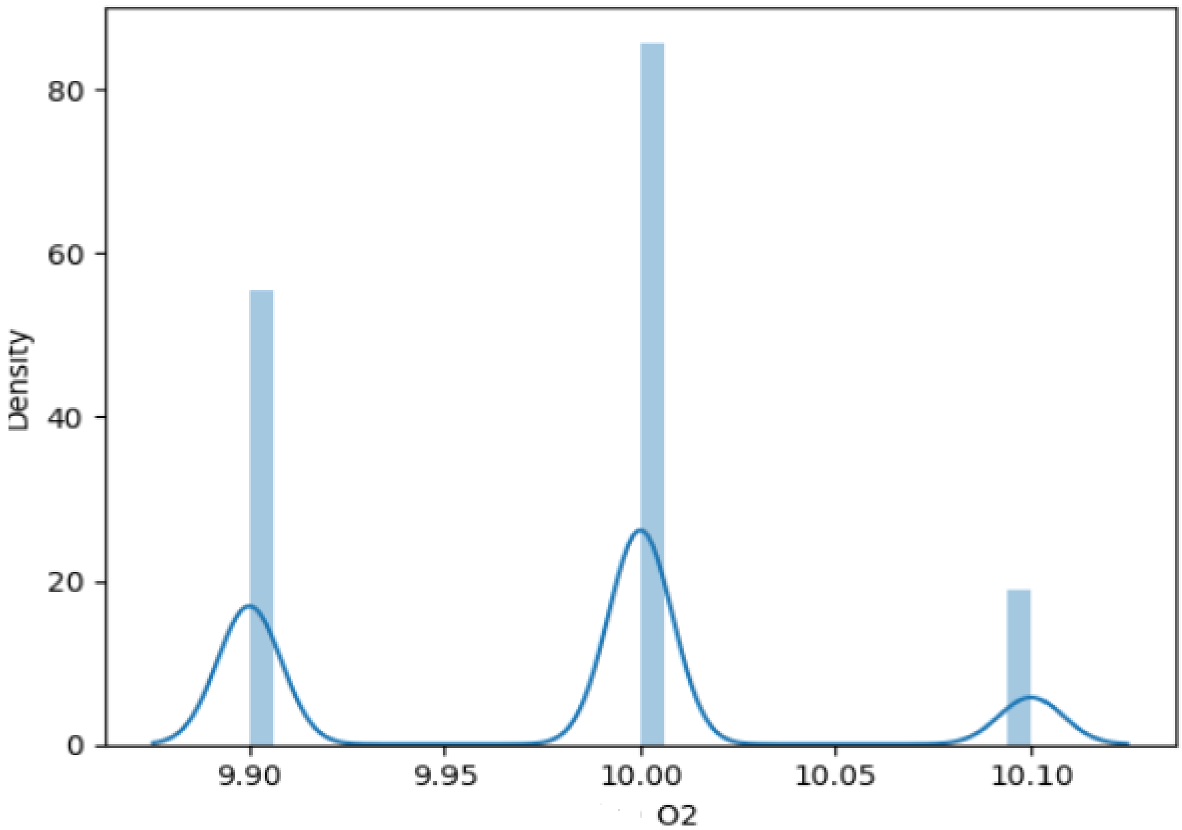

Figure 28 : Shows air O2 changes in the Traditional poultry house**.**

III.3.2.2 The relative humidity

Chicken feed efficiency, feathering, pigmentation, and weight gain are all negatively impacted by an external temperature greater than 26.7°C combined with a high relative humidity [29]. Moreover, the birds performed poorly at an internal temperature range of 35–37.8 °C. Higher humidity combined with lower temperatures can therefore increase bird performance regardless of changes in relative humidity. However, humidity levels must be managed to prevent microorganisms, which can infect birds and cause deadly diseases[37, 61].

Temperature change and relative humidity have a strong correlation.Due to the necessity to warm the chicks at that age, or because the baby chickens are thirsty after they hatch, the interior relative humidity might be low during the brooding stage, especially in the early weeks. greater warmth. The water vapor produced by the evaporative cooling eventually causes the internal relative humidity to rise, causing the chicken to regulate its body temperature as it grows [62]. Therefore, regardless of the type of chicken, the ages of three weeks and older are crucial for the development of chickens.

Tableau 4 :ideal humidity level for broiler chicks.

Chick Age (Days)	**Humidity in Poultry House**
1	62%-60%
7	60%-50%
14	50%-46%
21	46%-40%
28-45	40%

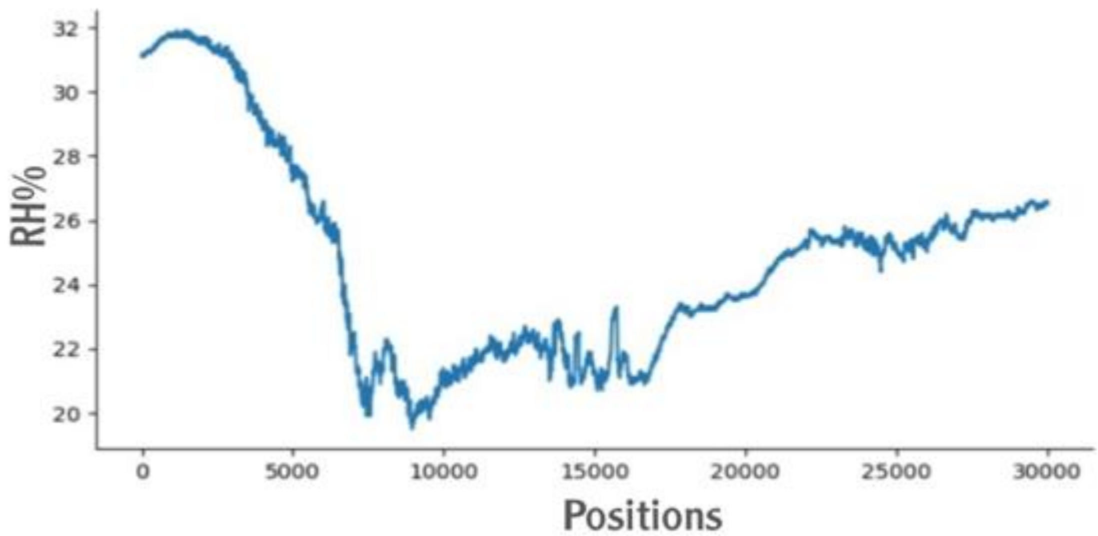

Figure 29 : Ambient relative humidity of traditional buildings .RH %

The relationship between ambient temperature and humidity is important for chickens because it directly impacts their thermal comfort. When the temperature is high, chickens may struggle to regulate their body temperature effectively. If the air also contains high levels of moisture, the humidity can make it even more difficult for the chickens to cool down through evaporation.

High humidity can also lead to overheating in chickens because it hinders their ability to release excess body heat. When the air is already saturated with moisture, the chickens' sweat and panting mechanisms may not be as effective in cooling them down. This can result in heat stress, which can have serious consequences for the health and well-being of the chickens.

Therefore, it is important for chicken farmers to monitor both the temperature and humidity levels in their poultry houses to ensure that the conditions are optimal for the chickens' comfort and well-being. By maintaining a balancebetween temperature and humidity, farmers can help prevent heat stress and ensure that their chickens are able to thrive in their environment.

Warm air can possess more water vapor (moisture) than cold air, so with the same amount of absolute/specific humidity.

III.3.2.3 Temperature

There is discussion on the suitable temperature range that is needed for various age groups and chicken classes to achieve optimal production; this is connected to other meteorological parameters like humidity and wind speed that affect temperature change and prior adaptability of chicken to shifting weather patterns. [29]
All classes and ages of chicken typically function well in a range of temperatures, but severe heat exposure hinders the performance of chicken production.
Its poor impact on evaporative cooling may also be exacerbated by an increase in relative humidity.[63] .30 to 32°C is the ideal temperature for day-old chicks [62]. After then, the temperature should be lowered by 3 to 4°C until the chicks are 4 weeks old, as indicated in **Table 5**.According to reports, broiler growth requires a temperature range of 18–22°C [38]. In After doing additional investigations, it was shown that birds find comfort in temperatures ranging from 18 to 24°C. [64] It is worth noting, however, that the ideal performance of chickens is correlated with the product's market value in relation to feed costs.

Tableau 5 : Recommended ranges of temperatures.

Age of Chicken	Temperature Range (°C)
1	30-32
2	30-26
3	26-23
4	23-20
≥5	20

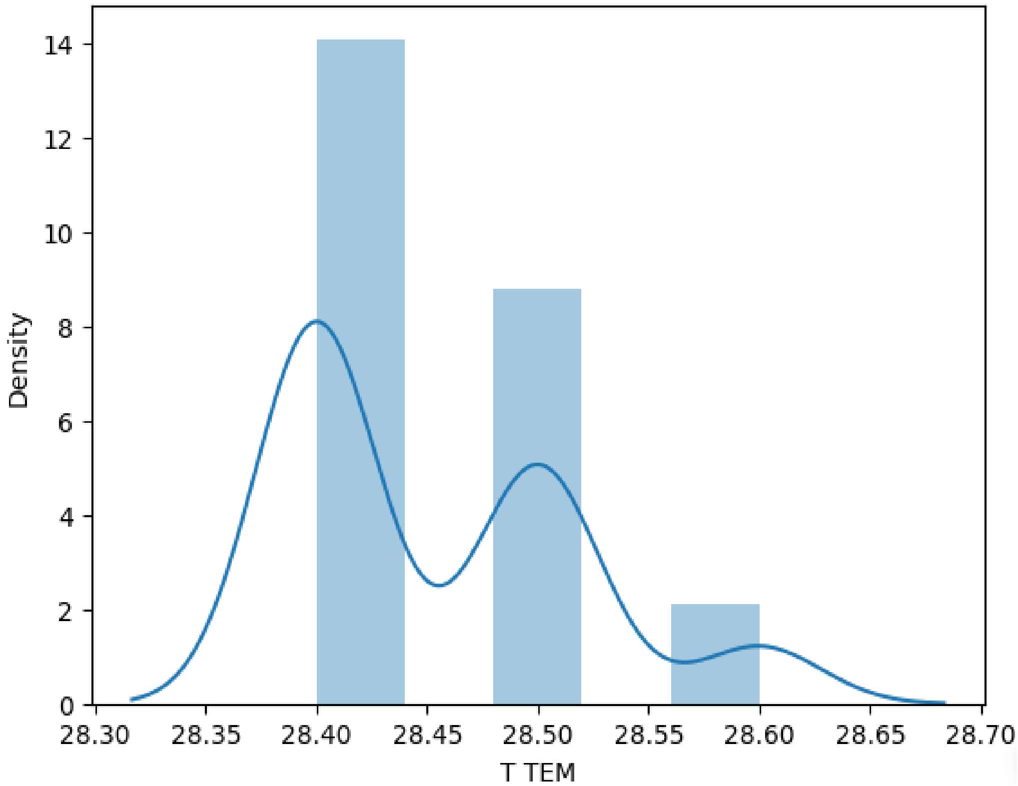

Figure 30: Ambienttemperature for conventionalpoultryhouses

III.3.3 The impact of geothermal energy on temperature, humidity, and air quality in poultry houses (Modern poultry farmer.)

III.3.3.1 Air

In poultry buildings, geothermal systems are a major factor in improving air quality. Geothermal energy reduces indoor air pollution and makes it unnecessary to use chemical-based cooling systems or combustion-based heating systems, improving the environment for both agricultural workers and birds. Conventional heating techniques, such as burning fossil fuels, can generate dangerous pollutants such as nitrogen oxides and carbon monoxide, which are extremely dangerous to human and chicken health. Poultry farmers can reduce these risks and ensure better air inside their buildings by switching to geothermal energy.

Geothermal systems also help poultry buildings have greater ventilation and air circulation, further improving air quality. Bird health can be compromised by excess moisture, airborne pollutants and odors, all of which must be removed through proper ventilation. To maintain optimal air flow and air exchange rates, geothermal systems can be connected to advanced ventilation systems, giving poultry a fresh atmosphere. And a healthyenvironment[65].

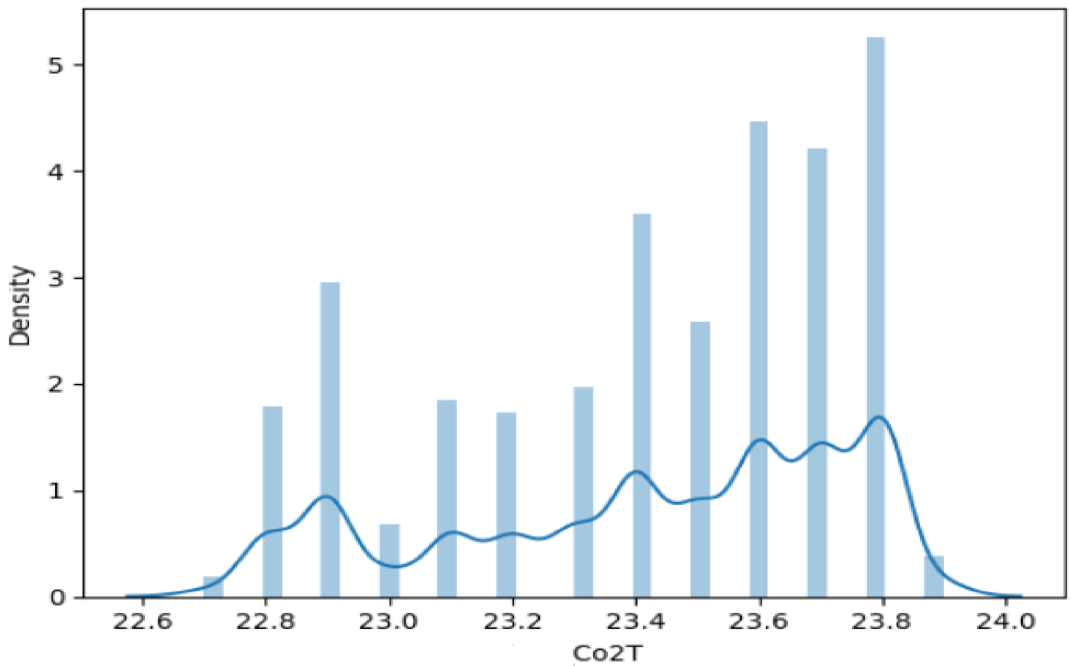

Figure 31: The impact of geothermal energy on Air (CO2).

Geothermal energy can have a positive impact on the levels of carbon dioxide (CO2) in the air in a poultry farm. Geothermal energy is a renewable and sustainable source of power that harnesses heat from the Earth's core to generate electricity and heat.

By using geothermal energy to power heating and ventilation systems in a poultry farm, farmers can reduce the reliance on fossil fuels, which are a major source of carbon dioxide emissions. This can help decrease the overall carbon footprint of the poultry farm and contribute to lower levels of CO_2 being released into the atmosphere.

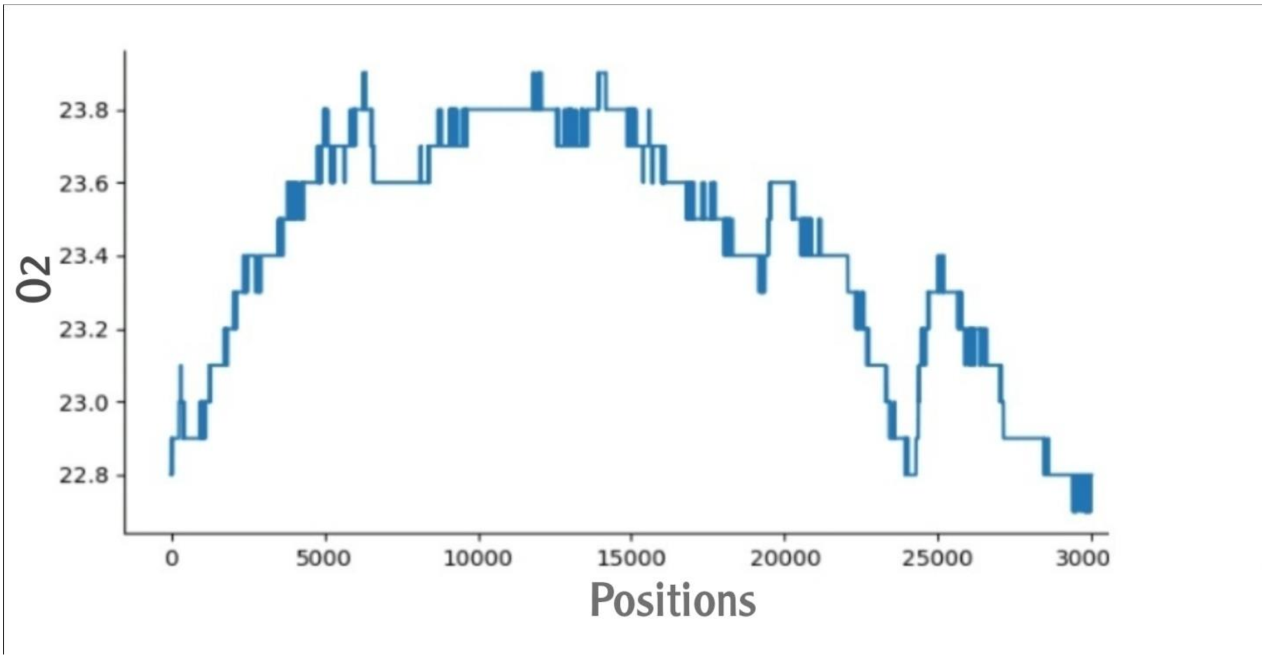

Figure 32: The impact of geothermal energy on Air (O_2).

Geothermal energy can have a positive impact on the air quality, specifically the oxygen levels, in a poultry farm. Geothermal energy is a renewable and sustainable source of power that harnesses heat from the Earth's core to generate electricity and heat**.**

III.3.3.2 Humidity:

Humidity control is essential to the welfare and production of chickens. Since geothermal systems control the temperature inside chicken houses, they indirectly help regulate humidity. These systems maintain a constant temperature and prevent excessive moisture buildup, which can cause mold growth, respiratory problems and other health concerns for birds. Maintaining a constant temperature helps keep the relative humidity within the ideal range, giving your chickens a comfortable and healthy environment.

Humidity control in poultry houses can be improved by combining geothermal systems with dehumidification technology. These devices improve overall air quality, reduce the chance of bacteria and fungi growth, and stop condensation on surfaces by removing excess moisture from the air. The structure of a poultry house can be maintained by properly controlling humidity, which also benefits the birds' health by avoiding problems such as corrosion and structural damage caused by moisture buildup [66].

III.3.3.3 Temperature

Geothermal energy can be utilized in poultry houses to regulate and maintain optimal temperatures for bird health and productivity.

Geothermal systems can help in heating poultry houses during colder periods and cooling them in warmer seasons, ensuring a comfortable environment for the birds By harnessing geothermal energy, poultry farmers can reduce their reliance on traditional heating and cooling methods, leading to potential cost savings and energy efficiency

The use of geothermal energy can contribute to more stable and consistent temperatures within poultry houses, which is crucial for the well-being and performance of the birds

Geothermal systems can help mitigate temperature fluctuations, creating a more controlled and favorable climate for poultry, ultimately improving their growth rates and overall productivity

Utilizing geothermal energy in poultry houses can have a significant positive impact on temperature regulation, bird welfare, and overall production efficiency.

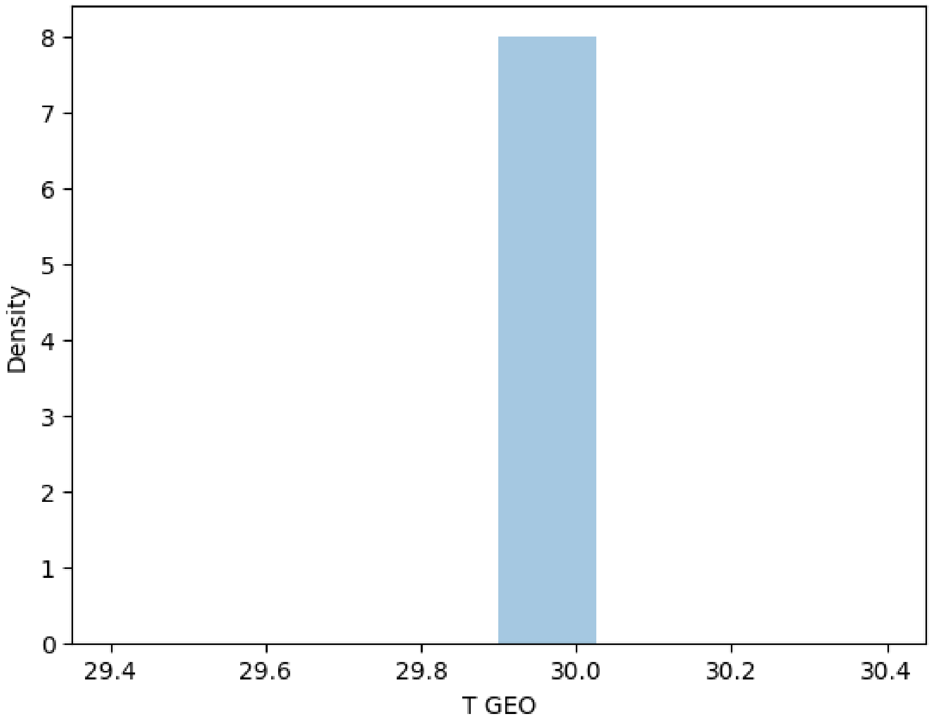

Figure 33: The impact of geothermal energy on Temperature.

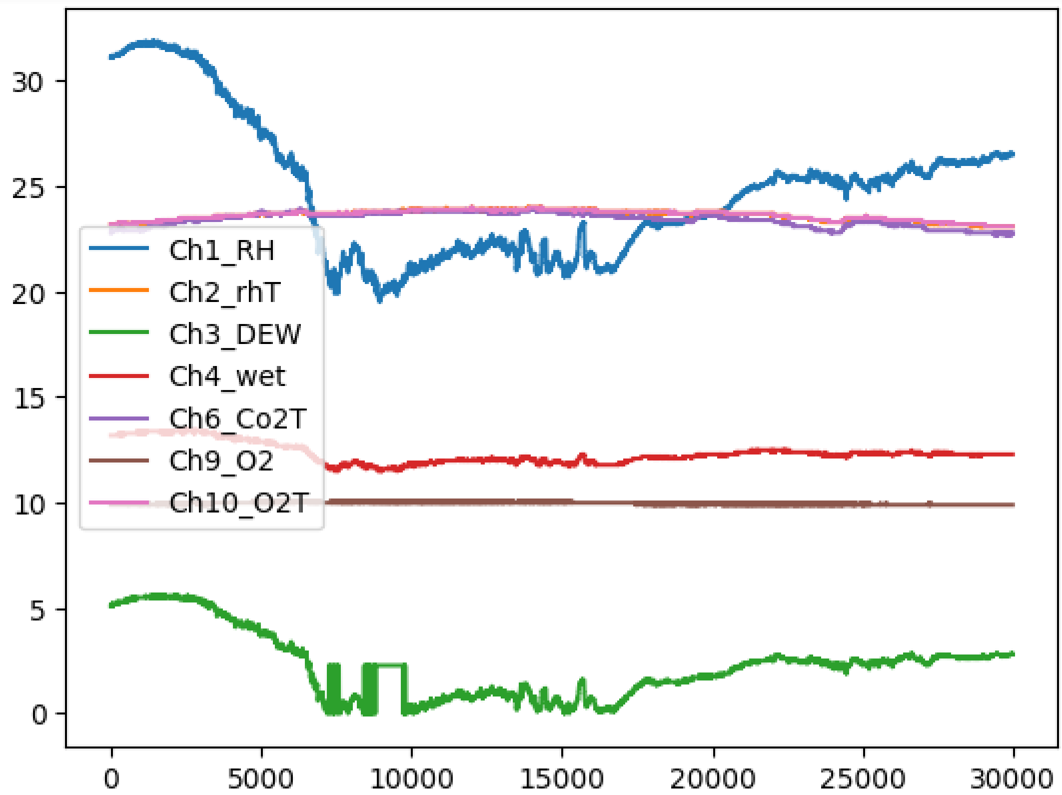

Figure 34 : Changes in the environment of poultry houses with the presence and absence of thermal energy

III.4 Conclusion :

The environment of poultry houses with geothermal energy is typically more stable and energy-efficient compared to poultry houses without geothermal energy. Geothermal energy utilizes the natural heat from the Earth's core to regulate the temperature inside the poultry house. This means that the poultry house can be kept at a consistent and optimal temperature throughout the year, reducing the need for additional heating or cooling systems.

Poultry houses with geothermal energy also tend to have better air quality and ventilation due to the controlled temperature and humidity levels. This can result in improved health and productivity of the poultry, as well as reduced risk of diseases and stress-related issues.

On the other hand, poultry houses without geothermal energy may rely on traditional heating and cooling methods, such as gas or electric heaters, which can be less efficient and more expensive to operate. The temperature inside these poultry houses may fluctuate more, leading to potential health issues for the poultry and higher energy costs for the farmer.

In summary, poultry houses with geothermal energy offer a more stable, energy-efficient, and environmentally friendly environment for raising poultry compared to poultry houses without this technology.

Conclusion

General conclusion :

In poultry buildings, geothermal energy has a major effect on air quality, humidity, and temperature. Geothermal energy systems assist in controlling the temperature inside the poultry house, keeping it at a steady and ideal level all year round by harnessing the natural heat from the Earth's core. The chickens are kept in a comfortable atmosphere that supports their growth, health, and general well-being because of the steady temperature.

Geothermal energy systems are used in chicken houses to regulate humidity levels in addition to temperature. Geothermal energy assists in preventing excessive humidity, which can result in problems like dampness, condensation, and mold development, by preserving the proper temperature.

In addition to improving the quality of the air, this regulated humidity level lowers the chance of respiratory issues and disease transmission among the fowl.

Furthermore, the system's creation of steady humidity and temperature levels contributes to the better air quality in poultry buildings using geothermal energy. The atmosphere around the chickens is healthier because to improved air circulation, lower concentrations of dangerous gasses, dust, and pathogens, and generally cleaner air. The birds may benefit from better respiratory health, less stress, and increased output as a result of this.

Geothermal energy has a considerable overall effect on temperature, humidity, and air quality in poultry buildings, resulting in a more stable, cozy, and healthful environment for the birds to live in.

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Abstract:

The use of geothermal energy in poultry facilities provides a stable and environmentally friendly environment by utilizing the Earth's natural heat to maintain optimal temperatures, enhancing poultry health and productivity. This renewable energy source, derived from the ground, reduces energy costs and improves air quality compared to traditional heating methods. Geothermal energy, harnessed through various means such as power plants and heat pumps, is sustainable with minimal greenhouse gas emissions, making it an environmentally conscious choice for heating and cooling systems.

Keywords:

- Poultry farming, geothermal energy, temperature control, humidity regulation, air quality, sustainability, energy efficiency.

خلاصة:

يوفر استخدام الطاقة الحرارية الأرضية في منشآت الدواجن بيئة مستقرة وصديقة للبيئة من خلال الاستفادة من الحرارة الطبيعية للأرض للحفاظ على درجات الحرارة المثلى، وتعزيز صحة الدواجن وإنتاجيتها. مصدر الطاقة المتجددة هذا، المستمد من الأرض، يقلل من تكاليف الطاقة ويحسن جودة الهواء مقارنة بطرق التدفئة التقليدية. الطاقة الحرارية الأرضية، التي يتم تسخيرها من خلال وسائل مختلفة مثل محطات توليد الطاقة والمضخات الحرارية، مستدامة مع الحد الأدنى من انبعاثات الغازات الدفيئة، مما يجعلها خيارًا واعيًا بيئيًا لأنظمة التدفئة والتبريد.

الكلمات المفتاحية:

- تربية الدواجن، الطاقة الحرارية الأرضية، التحكم في درجة الحرارة، تنظيم الرطوبة، جودة الهواء، الاستدامة، كفاءة الطاقة.